WST03/01: Statistics S3

Question Number		Scheme			Marks
Q3	(a)	$E \sim N(0, 0.5^2)$ or $X \sim N(w, 0.5^2)$			
		$P(|E| < 0.6) = P\left(|Z| < \dfrac{0.6}{0.5}\right)$ or $P(|X - w| < 0.6) = P\left(|Z| < \dfrac{0.6}{0.5}\right)$			M1
		$= P(|Z| < 1.2)$			
		$= 2 \times 0.8849 - 1 = 0.7698$		awrt **0.770**	A1
					(2)
	(b)	$\bar{E} \sim N\left(0, \dfrac{1}{64}\right)$ or $\bar{X} \sim N\left(w, \dfrac{0.5^2}{16}\right)$			M1
		$P(|\bar{E}| < 0.3) = P\left(|Z| < \dfrac{0.3}{\frac{1}{8}}\right)$ or $P(|\bar{X} - w| < 0.3) = P\left(|Z| < \dfrac{0.3}{\frac{1}{8}}\right)$			M1, A1
		$= P(|Z| < 2.4)$			
		$= 2 \times 0.9918 - 1 = 0.9836$		awrt **0.984**	A1
					(4)
	(c)	$35.6 \pm 2.3263 \times \dfrac{1}{8}$			M1 B1
		(**35.3, 35.9**)			A1, A1
					(4)
					10

(a) 1st M1   for identifying a correct probability (they must have the 0.6) and attempting to standardise. Need $|\ |$. This mark can be given for 0.8849 - 0.1151 seen as final answer.

   1st A1   for awrt 0.770.   NB an answer of 0.3849 or 0.8849 scores M0A0 (since it implies no $|\ |$)

   M1 may be implied by a correct answer

(b) 1st M1   for a correct attempt to define $\bar{E}$ or $\bar{X}$ but must attempt $\dfrac{\sigma^2}{n}$.

   Condone labelling as E or X
   This mark may be implied by standardisation in the next line.

   2nd M1   for identifying a correct probability statement using $\bar{E}$ or $\bar{X}$. Must have 0.3 and $|\ |$

   1st A1   for correct standardisation as printed or better

   2nd A1   for awrt 0.984

   The M marks may be implied by a correct answer.

Sum of 16, not means

   1st M1   for correct attempt at suitable sum distribution with correct variance ($= 16 \times \frac{1}{4}$)

   2nd M1   for identifying a correct probability. Must have 4.8 and $|\ |$

   1st A1   for correct standardisation i.e. need to see $\dfrac{4.8}{\sqrt{4}}$ or better

(c) M1   for $35.6 \pm z \times \dfrac{0.5}{\sqrt{16}}$

   B1   for 2.3263 or better. Use of 2.33 will lose this mark but can still score ¾

   1st A1   for awrt 35.3

   2nd A1   for awrt 35.9

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Question Number	Scheme	Marks

Q4

(a)

Distance rank	1	2	3	4	5	6	7
Depth rank	1	2	4	3	6	7	5
$|d|$	0	0	1	1	1	1	2
d^2	0	0	1	1	1	1	4

M1

M1

$$\sum d^2 = 8$$ M1A1

$$r_s = 1 - \frac{6 \times 8}{7 \times 48}$$ M1

$$= \frac{6}{7} = 0.\dot{8}5714\dot{2}$$ 　　　　　　　　　　　awrt **0.857** A1

(6)

(b) $H_0 : \rho = 0, H_1 : \rho > 0$ 　B1

Critical value at 1% level is 0.8929 　B1

$r_s < 0.8929$ so not significant evidence to reject H_0, 　M1

The researcher's claim is not correct (at 1% level). 　A1ft

<u>or</u> insufficient evidence for researcher's claim

<u>or</u> there is insufficient evidence that water gets deeper further from inner bank.

<u>or</u> no (positive) correlation between depth of water and distance from inner bank

(4)

10

(a) 1st M1 　　for an attempt to rank the depths against the distances

2nd M1 　　for attempting d for their ranks. Must be using ranks.

3rd M1 　　for attempting $\sum d^2$ (must be using ranks)

1st A1 　　for sum of 8 (or 104 for reverse ranking)

4th M1 　　for use of the correct formula with their $\sum d^2$. If answer is not correct an expression is required.

2nd A1 　　for awrt ($\pm$) 0.857. Sign should correspond to ranking (so use of 104 should get -0.857)

(b) 1st B1 　　for both hypotheses in terms of ρ, H_1 must be one tail and compatible with their ranking

2nd B1 　　for cv of 0.8929 (accept $\pm$)

M1 　　for a correct statement relating their r_s with their cv but cv must be such that |cv|<1

A1ft 　　for a correct contextualised comment. Must mention "researcher" and "claim" <u>or</u> "distance (from bank)" and "depth (of water)"

　　　Follow through their r_s and their cv (provided it is |cv| <1)

　　　Use of "association" is A0

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Question Number	Scheme					Marks
Q5	<table><tr><td>Finances Income</td><td>Worse</td><td>Same</td><td>Better</td><td></td></tr><tr><td>Under £15 000</td><td>10.54</td><td>10.54</td><td>12.92</td><td>34</td></tr><tr><td>£15 000 and above</td><td>20.46</td><td>20.46</td><td>25.08</td><td>66</td></tr><tr><td></td><td>31</td><td>31</td><td>38</td><td>100</td></tr></table>					M1 A1

H_0 : State of finances and income are independent (not associated)

H_1 : State of finances and income are not independent (associated)

B1

O_i	E_i	$\dfrac{(O_i - E_i)^2}{E_i}$	$\dfrac{O_i^2}{E_i}$
14	10.54	1.1358….	18.59..
11	10.54	0.0200….	11.48..
9	12.92	1.1893…	6.269..
17	20.46	0.5851…	14.12..
20	20.46	0.0103…	19.55..
29	25.08	0.6126…	33.53..

M1

A1

$$\sum \frac{(O_i - E_i)^2}{E_i} = 3.553\ldots \quad \text{or} \quad \sum \frac{O_i^2}{E_i} - 100 = 103.553... - 100 = 3.553... \quad \text{(awrt } \mathbf{3.55})$$ A1

$v = (3-1)(2-1) = 2$ B1

cv is 5.991   B1

3.553 < 5.991 so insufficient evidence to reject H_0 <u>or</u> not significant   M1

There is no evidence of association between state of finances and income.   A1

10

1st M1	for some use of $\dfrac{\text{Row Total} \times \text{Col.Total}}{\text{Grand Total}}$. May be implied by correct E_i
1st A1	for all expected frequencies correct
B1	for both hypotheses. Must mention "state" or "finances" and "income" at least once Use of "relationship" or "correlation" or "connection"is B0
2nd M1	for at least two correct terms (as in 3rd or 4th column) or correct expressions with their E_i
2nd A1	for all correct terms. May be implied by a correct answer.(2 dp or better-allow eg 1.13…)
3rd M1	for a correct statement linking their test statistic and their cv . Must be χ^2 not normal.
4th A1	for a correct comment in context - must mention "state" or "finances" and "income" condone "relationship" or "connection" here but **not** "correlation". No follow through. e.g. "There is no evidence of a relationship between finances and income"

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Question Number	Scheme	Marks
Q6		

Distance from centre of site (m)	0-1	1-2	2-4	4-6	6-9	9-12	
$b-a$	1	1	2	2	3	3	M1
No of artefacts	22	15	44	37	52	58	
$P(a \le X < b)$	$\frac{1}{12}$	$\frac{1}{12}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{4}$	A1
$228 \times P(a \le X < b)$	19	19	38	38	57	57	A1

Class	O_i	E_i	$\dfrac{(O_i - E_i)^2}{E_i}$	$\dfrac{O_i^2}{E_i}$	Marks
0-1	22	19	$\frac{9}{19} = 0.4736...$	$25.57...$	
1-2	15	19	$\frac{16}{19} = 0.8421...$	$11.84...$	M1
2-4	44	38	$\frac{36}{38} = 0.9473...$	$50.94...$	
4-6	37	38	$\frac{1}{38} = 0.0263...$	$36.02...$	
6-9	52	57	$\frac{25}{57} = 0.4385...$	$47.43...$	A1
9-12	58	57	$\frac{1}{57} = 0.0175...$	$59.01...$	

H_0: <u>continuous uniform</u> distribution <u>is</u> a good fit   B1
H_1: <u>continuous uniform</u> distribution <u>is not</u> a good fit

$$\sum \frac{(O_i - E_i)^2}{E_i} = \frac{313}{114} = 2.75 \quad \underline{or} \quad \sum \frac{O_i^2}{E_i} - 228 = 230.745... - 228 = ... \quad \text{(awrt } \mathbf{2.75})$$ dM1A1

$\nu = 6 - 1 = 5$ B1

$\chi_5^2(0.05) = 11.070$ (ft their ν i.e. $\chi_\nu^2(0.05)$)   B1ft

$2.75 < 11.070$, insufficient evidence to reject H_0 M1

Continuous uniform distribution is a suitable model   A1

12

1st M1	for calculation of at least 3 widths and attempting proportions/probs. <u>or</u> for 1:2:3 ratio seen
1st A1	for correct probabilities
2nd A1	for all correct expected frequencies
2nd M1	for attempting $\dfrac{(O-E)^2}{E}$ or $\dfrac{O^2}{E}$, at least 3 correct expressions or values. Follow through their E_i provided they are not all $= 38$
3rd A1	for a correct set of calcs - 3rd or 4th column. (2 dp or better and allow e.g. 0.94...)
3rd dM1	**dependent on 2nd M1** for attempting a correct sum or calculation (must see at least 3 terms and +) **The first three Ms and As can be implied by a test statistic of awrt 2.75**
4th M1	for a correct statement based on their test statistic (> 1) and their cv (> 3.8) Contradictory statements score M0 e.g. "significant" do not reject H_0.
5th A1	for a correct comment suggesting that continuous uniform model is suitable. No ft

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Question Number		Scheme	Marks
Q7	(a)	Label full time staff 1-6000, part time staff 1-4000	M1
		Use random numbers to select	M1
		Simple random sample of 120 full time staff and 80 part time staff	A1 (3)
	(b)	Enables estimation of statistics / errors for each strata <u>or</u> "reduce variability" <u>or</u> "more representative" <u>or</u> "reflects population structure" **NOT** "more accurate"	B1 (1)
	(c)	$H_0: \mu_f = \mu_p$, $H_1: \mu_f \neq \mu_p$ (accept μ_1, μ_2)	B1
		s.e. $= \sqrt{\dfrac{21}{80} + \dfrac{19}{80}}$, $z = \dfrac{52-50}{\sqrt{\dfrac{21}{80} + \dfrac{19}{80}}} = \left(2\sqrt{2}\right)$	M1,M1
		$= 2.828\ldots$ (awrt **2.83**)	A1
		Two tailed critical value z = 2.5758 (or prob of awrt 0.002 (<0.005) or 0.004 (<0.01))	B1
		[2.828 > 2.5758 so] significant evidence to reject H_0	dM1
		There is evidence of a difference in policy awareness between full time and part time staff	A1ft (7)
	(d)	Can use mean full time and mean part time	B1
		~ Normal	B1 (2)
	(e)	Have assumed $s^2 = \sigma^2$ or variance of sample = variance of population	B1 (1)
	(f)	2.53 < 2.5758, not significant <u>or</u> do not reject H_0	M1
		So there is insufficient evidence of a difference in mean awareness	A1ft (2)
	(g)	Training course has closed the gap between full time staff and part time staff's mean awareness of company policy.	B1 (1)
			17

(a) 1st M1   for attempt at labelling full-time and part-time staff. One set of correct numbers.
2nd M1   for mentioning use of random numbers
1st A1   for s.r.s. of 120 full-time and 80 part-time

(c) 1st M1   for attempt at s.e. - condone one number wrong . NB correct s.e. $= \sqrt{\frac{1}{2}}$

2nd M1   for using their s.e. in correct formula for test statistic. Must be $\dfrac{\pm(52-50)}{\sqrt{\frac{p}{q}+\frac{r}{s}}}$

3rd dM1   **dep. on 2nd M1** for a correct statement based on their normal cv and their test statistic
2nd A1   for correct comment in context. Must mention "scores" or " policy awareness" and types of "staff". Award **A0** for a one-tailed comment. Allow ft

(d) 1st B1   for mention of mean(s) <u>or</u> use of $\bar{X}$, provided $\bar{X}$ clearly refers to full-time or part-time
2nd B1   for stating that distribution can be assumed normal
e.g. "mean score of the test is normally distributed" gets B1B1

(f) M1   for correct statement (may be implied by correct contextualised comment)
A1   for correct contextualised comment. Accept "no difference in mean scores". Allow ft

(g) B1   for correct comment in context that implies training was effective.
This must be supported by their (c) and (f). Condone one-tailed comment here.