Pearson Edexcel

Mark Scheme (Topic Test)

Type I and Type II Errors, Power

Pearson Edexcel GCE
In Statistics (9ST0)

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General Marking Guidance

Total marks

The total number of marks for the paper is 50.

Mark types

The Edexcel Statistics mark schemes use the following types of marks:

- **M** **Method** marks,
  awarded for 'knowing a method and attempting to apply it',
  unless otherwise indicated.
- **A** **Accuracy** marks can only be awarded if the relevant method (M) marks have been earned.
- **B** **Unconditional accuracy** marks are independent of M marks
- **E** **Explanation** marks

NOTE: Marks should not be subdivided.

Abbreviations

These are some of the marking abbreviations that will appear in the mark schemes.

- ft follow through
- PI possibly implied
- cao correct answer only
- cso correct solution only
  (There must be no errors in this part of the question)
- awrt answers which round to
- awfw answers which fall within (a given range)
- SC special case
- nms no method shown
- oe or equivalent
- dep dependent (on a given mark or objective)
- dp decimal places
- sf significant figures
- ∗ The answer is printed on the paper

Further notes

- 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.
- All A marks are 'correct answer only' (cao), unless shown, for example, as A1ft to indicate that previous wrong working is to be followed through.
- All M marks are 'possibly implied' (PI) unless specifically stated otherwise in the 'Notes' column.
- After a **misread**, the subsequent A marks affected are treated as A1ft, but manifestly absurd answers should never be awarded A marks.
- **Crossed out** work should be marked UNLESS the candidate has replaced it with an alternative response.
- If **two solutions** are given, each should be marked, and the resultant mark should be the mean of the two marks, rounded down to the nearest integer if needed.

Question	Scheme	Marks	AO	Notes
1(a)	Rejecting H_0 when in reality H_0 is true	E1	1.3	oe Do not allow mention of "probability"
1(b)	Not rejecting H_0 when in reality H_0 is false	E1	1.3	oe Do not allow mention of "probability"
1(c)	The probability of correctly rejecting H_0	E1	1.3	Must see "probability"
1(d)	**Method** Decrease the significance level	B1	1.1	
	Disadvantage Increases the probability of making a Type II error OR Decreases the power	E1	3.1a	
1(e)	**Method** Increase the significance level	B1	1.1	
	Disadvantage Increases the probability of making a Type I error	E1	3.1a	
	Alternatively:			
	Method Increase the sample size	(B1)		
	Disadvantage May not be practical / takes longer / may not be cost-effective etc.	(E1)		Allow any sensible practical disadvantage to taking a larger sample
1(f)	0.726	B1	1.3	cao
	Total	**8**		

Question	Scheme	Marks	AO	Notes
2(a)	[X = the number of first day views]			
	H_0: $\mu = 1902$ H_1: $\mu > 1902$	B1	1.3	Both oe
	Method 1: Using $\overline{X}$			
	$\overline{x} = 1976.0833$ ...	B1	1.3	awrt 1976
	$N\left(1902, \frac{97.8^2}{12}\right)$	M1	1.3	$\frac{97.8^2}{12}$ seen or implied
	CV = 1948.438213…	A1	1.3	awrt 1948 or p = awrt 0.004
	"1976" > "1948" Reject H_0	M1	2.1b	Their TS compared with their CV (or p compared with 0.05) and correct decision made
	There is significant evidence to suggest the mean number of first day views has increased since the viral post	E1	2.1a	Dep on correct TS and CV (or p) Must not be definite Must be in context
	Method 2: Using Z			
	$\overline{x} = 1976.0833$ ...	(B1)		awrt 1976
	$\frac{1976.08333 - 1902}{\frac{97.8}{\sqrt{12}}}$	(M1)		$\frac{97.8}{\sqrt{12}}$ seen or implied
	$= 2.624050952$ ...	(A1)		awrt 2.62 or p = awrt 0.004
	"2.624" > 1.645 Reject H_0	(M1)		Their TS compared with 1.645 (or p compared with 0.05) and correct decision made
	There is significant evidence to suggest the mean number of first day views has increased since the viral post	(E1)		Dep on correct TS and CV (or p) Must not be definite Must be in context

Question	Scheme	Marks	AO	Notes
2(b)	**Method 1: Using $\overline{X}$**			
	$W \sim \text{N}\left(1950, \frac{97.8^2}{12}\right)$	M1	1.3	Seen or implied
	Either: $1 - \text{P}(W \leq 1948)$ OR $\text{P}(W \geq 1948)$	M1ft	1.3	FT their CV from (a)
	$= 0.522$	A1	1.3	awfw 0.52~0.53
	Method 2: Using Z			
	$W \sim \text{N}\left(\frac{1950 - 1902}{\frac{97.8}{\sqrt{12}}}, 1\right)$ $\left(= \text{N}(1.70, 1)\right)$	(M1)		Attempt to standardise 1950
	Either: $1 - \text{P}(W \leq 1.645)$ OR $\text{P}(W \geq 1.645)$	(M1ft)		FT their CV from (a)
	$= 0.522$	(A1)		awfw 0.52~0.53
2(c)	If the mean number of first day views is 1950, the probability of correctly concluding that the mean number of first day views has increased is 0.522	E1	2.1a	
	Total	**10**		

Question	Scheme	Marks	AO	Notes
3(a)	[X = the number of female employees appointed]			
	B$(25, 0.48)$	B1	1.3	Seen or implied
	$\mathrm{P}(X \leq 6) = 0.0124 < 0.025$ $\mathrm{P}(X \leq 7) = 0.0342 > 0.025$	M1	1.3	Both
	$\mathrm{P}(X \geq 17) = 0.035 > 0.025$ $\mathrm{P}(X \geq 18) = 0.013 < 0.025$	M1	1.3	Both Allow $\mathrm{P}(X \leq 16) = 0.965 < 0.975$ and $\mathrm{P}(X \leq 17) = 0.987 > 0.975$
	Critical region: $X \leq 6$ and $X \geq 18$	A1	1.3	Both
3(b)	H_0: $\pi = 0.48$ H_1: $\pi \neq 0.48$	B1	1.3	Both oe
	$6 < 7 < 18$ Do not reject H_0	M1	2.1b	Allow statement e.g. "7 is not inside critical region" OR $p = 0.0342 < 0.025$ OR $p = 0.0685 > 0.05$
	There is insufficient evidence to suggest the proportion of females appointed by the company is different to 48%	E1	2.1a	Dep on correct CVs or p Must not be definite Must be in context
3(c)	$"0.0124" + "0.013" = 0.0256$	B1ft	1.3	FT their values from (a)
3(d)	B$(25, 0.45)$	B1	1.3	Seen or implied
	$\mathrm{P}(7 \leq \mathrm{X} \leq 17)$	M1	1.3	FT the complement of their critical region
	$= 0.9684124152\ldots$	A1	1.3	awrt 0.968
3(e)	0.968	B1ft	1.3	FT their part (d)
	Total	**12**		

Question	Scheme	Marks	AO	Notes
4(a)	[X = increase in average no. of steps per day for the standard device Y = increase in average no. of steps per day for the gamified device]			
	H_0: $\mu_Y - \mu_X = 0$ H_1: $\mu_Y - \mu_X > 0$	B1	1.3	Both oe Subscripts must be clearly defined for B1
	Method 1: Using Z			
	$\dfrac{(197.73 - 149.25) - 0}{\sqrt{\dfrac{4622.25}{143} + \dfrac{5241.83}{97}}}$	M1	1.3	Difference in means in numerator
		M1	1.3	Correct denominator
	$= 5.2167$ ...	A1	1.3	awrt $(\pm)5.22$ or $p = 9.1 \times 10^{-8}$
	CV = $(\pm)$ 1.645	B1	1.3	Ignore sign
	"|5.22|" > "1.645"	M1	2.1b	Their TS compared with their CV (or p with 0.05) and correct decision made TS and CV must have same sign
	There is significant evidence to suggest a higher increase in the average number of steps per day for those wearing the gamified device than the standard device	E1	2.1a	Dep on correct TS and CV (or p) Must not be definite Must be in context
	Method 2: Using linear combinations			
	$\overline{Y} - \overline{X} \sim \text{N}\left(0, \dfrac{4622.25}{143} + \dfrac{5241.83}{97}\right)$	(M1)		Sum of variances seen or implied
	TS = $197.73 - 149.25$	(M1)		Difference in means
	$= 48.48$	(A1)		awrt 48.5 or $p = 9.1 \times 10^{-8}$
	CV = $(\pm)$ 15.28	(B1)		Ignore sign
	"|48.48|" > "15.28"	(M1)		Their TS compared with their CV (or p with 0.05) and correct decision made TS and CV must have same sign
	There is significant evidence to suggest a higher increase in the average number of steps per day for those wearing the gamified device than the standard device	(E1)		Dep on correct TS and CV (or p) Must not be definite Must be in context
4(b)(i)	Concluding that there is a higher mean increase in the average number of steps for those wearing the gamified device than the standard device, when in fact there is no difference	E1	2.1a	Must be in context
4(b)(ii)	$\text{P(Type I Error)} = 0.05$	B1	1.3	cao

Question	Scheme	Marks	AO	Notes
4(c)	Concluding that there is no difference in increase in the average number of steps taken by users between the two devices, when in fact the users wearing the gamified device have a higher average increase than those using the standard device.	E1	2.1a	Must be in context
4(d)	**Method 1: Using *Z***			
	$W \sim \mathrm{N}\left(\dfrac{30-0}{\sqrt{\dfrac{4622.25}{143}+\dfrac{5241.83}{97}}}, 1\right) \left(= \mathrm{N}(3.228\ldots, 1)\right)$	M1	1.3	Attempt to standardise 30
	$\mathrm{P}(W \leq 1.64)$	M1	1.3	Correct side of CV FT their CV from (a)
	$= 0.05667\ldots$	A1	1.3	awfw 0.056~0.057
	Method 2: Using linear combinations			
	$W \sim \mathrm{N}\left(30, \dfrac{4622.25}{143}+\dfrac{5241.83}{97}\right)$	(M1)		
	$\mathrm{P}(W \leq 15.28)$	(M1)		Correct side of CV FT their CV from (a)
	$= 0.05667\ldots$	(A1)		awfw 0.056~0.057
	Total	**13**		

Question	Scheme	Marks	AO	Notes
5(a)	[X = number of components passed]			
	$X \sim \text{B}(20000, 0.96)$	B1	1.3	
	$\text{P}(X \leq 19134) = 0.0097 < 0.01$ $\text{P}(X \leq 19135) = 0.011 > 0.01$	M1	1.3	Both Probabilities given to a minimum of 2sf
	CR: $X \leq 19134$	A1	1.3	
5(b)	$X \sim \text{B}(20000, 0.958)$			
	$\mu = 19160$	B1	1.3	Cao
	$\sigma^2 = 804.72$	B1	1.3	Or $\sigma =$ awrt 28.4 B0 for $\sigma = 804.72$ or $\sigma^2 = 28.4$
	Either $\text{P}(X \leq 19134.5)$ or $1 - \text{P}(X \geq 19134.5)$	M1	1.3	Condone no CC
	$= 0.18434$ ...	A1	1.3	awrt 0.184 No CC: Condone 0.180
	Total	**7**		