Pearson

Mark Scheme (Final)

January 2026

International Advanced Level in Statistics

S3 WST03/01A

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General Marking Guidance

- 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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL IAL MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

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

   Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:

   - bod – benefit of doubt
   - ft – follow through
     - the symbol $\surd$ will be used for correct ft
   - cao – correct answer only
   - cso – correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC – special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp – decimal places
   - sf – significant figures
   - ∗ – The answer is printed on the paper or ag- answer given
   - ⌊ or d… – The second mark is dependent on gaining the first mark

4. All A marks are ‘correct answer only’ (cao), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected. If you are using the annotation facility on ePEN, indicate this action by ‘MR’ in the body of the script.

6. If a candidate makes more than one attempt at any question:
   a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   b) If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme		Marks
1. (a)	See tables below	Attempt to rank for distance **or** for commission. (at least four correct).	M1

Salesperson	***A***	***B***	***C***	***D***	***E***	***F***	***G***	***H***
Rank Distance	7	6	4	1	5	3	2	8
Rank Commission	8	5	7	3	1	2	6	4

Or

Salesperson	***A***	***B***	***C***	***D***	***E***	***F***	***G***	***H***
Rank Distance	2	3	5	8	4	6	7	1
Rank Commission	1	4	2	6	8	7	3	5

Question Number	Scheme		Marks
	$\sum d^2 = 1+1+9+4+16+1+16+16; = 64$	For finding the difference between each of the **ranks** and evaluating $\sum d^2$.	M1
		$\sum d^2 = 64$	
	$r_s = 1 - \dfrac{6(64)}{8(63)}; = 0.238095...$	Using $1 - \dfrac{6\sum d^2}{8(63)}$ with their $\sum d^2$	dM1;
		$\dfrac{5}{21}$ or awrt 0.238	A1
			[4]
(b)	$H_0 : \rho = 0$, $H_1 : \rho > 0$	Both hypotheses stated correctly	B1
	Critical Value $r_s = 0.6429$ or CR: $r_s \geqslant 0.6429$	Critical value of 0.6429	B1
	Either • Since $r_s = 0.238...$ <u>does not lie in</u> the <u>CR</u> • Result is <u>not significant</u> • Do not reject H_0 (accept H_0)	see notes	M1
	conclude that there is a <u>no positive correlation</u> between <u>distance</u> travelled and amount of <u>commission</u> received.	Conclusion in context	A1
			[4] **8**

Notes

1. (a)	1st M1	For an attempt to rank at least one row (at least 4 correct)
	2nd M1	For an attempt at d^2 row for their **ranks** (at least 4 correct or correct ft) (may be implied by $\sum d^2 = 64$)
	3rd dM1	**dependent on 1st M1** for use of $1 - \dfrac{6\sum d^2}{8(63)}$ with their $\sum d^2$
	A1	awrt 0.238
(b)	**1st B1**	Both hypotheses stated in terms of ρ or ρ_s. Must be attached to H_0 and H_1
	2nd B1	0.6429 or better
	M1	For a correct statement relating their r_s $\left(\lvert r_s \rvert < 1\right)$ with their c.v. where $0 <$ their c.v.< 1 (If a comparison is made it must be correct e.g. 0.238 > 0.05 is M0).
	A1	For a contextualised comment which is not rejecting H_0, which must mention "<u>no positive correlation</u>", "<u>distance</u>" and "<u>commission</u>". (Use of "association" is A0.) Follow through their r_s with their c.v. (provided 0<their c.v.< 1) Applying a two-tailed test scores a maximum of B0B1M1A0
	SC 2-tailed test	**So Award SC B0B1** for $H_0 : \rho = 0$, $H_1 : \rho \neq 0$ followed by critical value $r_s = (\pm)\,0.7381$ and allow access to the M1 mark only (if comparison is made, it must be correct with consistent signs).

Question Number	Scheme		Marks
2.	X follows a continuous unform distribution over $[\alpha - 3, 2\alpha + 3]$		
(a)	$\{\mathrm{E}(\bar{X}) = \mu =\}\ \dfrac{2\alpha + 3 + \alpha - 3}{2}$		M1
	$= \dfrac{3\alpha}{2}$. [So $\bar{X}$ is a] biased [estimator.]		A1
	bias $\left\{= \dfrac{3\alpha}{2} - \alpha\right\} = \pm\dfrac{\alpha}{2}$	bias $= \pm\dfrac{\alpha}{2}$	B1
			[3]
(b)	$k = \dfrac{2}{3}$	$\dfrac{2}{3}$	B1
			[1]
(c)	$\dfrac{3\alpha}{2} = \bar{X} \to \alpha = \dfrac{2}{3}\bar{X} = \dfrac{2}{3}(8)$	"their k" × their $\bar{x}$	M1
	Max value $= 2\left(\text{"}\dfrac{16}{3}\text{"}\right) + 3$	$2 \times$ "their α" $+ 3$ See notes	M1
	$= \dfrac{41}{3}$	$\dfrac{41}{3}$ or $13\dfrac{2}{3}$ or awrt 13.7	A1
			[3] **7**

Notes

(a)	**M1**	Using the formula $\left(\dfrac{a+b}{2}\right)$ or getting $\dfrac{3\alpha}{2}$
	A1	$\dfrac{3\alpha}{2}$ and concluding. Allow A1 for $\dfrac{3\alpha}{2} \neq \alpha$.
	Note	Also allow A1 for bias $= \pm\dfrac{\alpha}{2} \neq 0$
	B1	$\pm\dfrac{\alpha}{2}$
(b)	**B1**	o.e.
(c)	**1st M1**	An attempt to use the sample data given to find $\bar{x}$ and multiply by their k. Allow full expression for $\bar{x}$ or $\dfrac{\sum x}{n}$.
	Note	1st M1 can be implied by a correct method leading to $\alpha = \dfrac{16}{3}$
	2nd M1	$2 \times$ "their α" $+ 3$ where their α is a function of the sample mean – which is found by applying $\dfrac{\sum x}{n}$ from the data values given in the question.
	Note	$2(13) + 3 = 39$ is M0M0A0

Question Number	Scheme		Marks
3. (a)	H_0 : There is no association between **centre** and **result** (independent) H_1 : There is an association between **centre** and **result** (dependent)	Correct hypotheses with centre and result at least once	B1
	(table 1 below)	Some attempt at $\frac{\text{(Row Total)(Column Total)}}{\text{(Grand Total)}}$ Can be implied by at least one correct E_i to awrt 3 sf	M1
		All expected frequencies are correct to awrt 3 sf	A1
	(table 2 below)	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 for this mark (dep on 1st M1).	dM1
		At least 5 correct $\frac{(O-E)^2}{E}$ or $\frac{O^2}{E}$ terms to at least 2 sf **or** at least 5 correct (ft) expressions.	A1
	$X^2 = \sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E} - 620$;= awrt 7.52	For **applying** either $\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E} - 620$	M1
		awrt <u>**7.52**</u>	A1
	$\nu = (2-1)(3-1) = 2$	$\nu = 2$ (can be implied)	B1
	$\chi^2_2(0.05) = 5.991 \Rightarrow$ CR: $X^2 \geqslant 5.991$	<u>**5.991**</u> Allow ft on their stated d.f. < 6 For ft: 3.841, 7.815, 9.488, 11.070	B1ft
	[in the CR/significant/Reject H_0] conclude that there is <u>an association</u> between driving test <u>centre</u> and <u>result</u>. (or they are <u>not independent</u>.)	A correct conclusion in context which is rejecting H_0 based on ***their*** X^2-value and ***their*** χ^2-critical value. Dep on 3rd M1 and 3rd B1ft. Do not allow contradictory statements. If hypotheses wrong way around, A0.	A1
			[10]
(b)	Test centre C	C	B1
	• e.g. High values of $\frac{(O-E)^2}{E}$ / contributes most to X^2 test statistic • Condone e.g. Observed and expected differences are bigger [for test centre C than for any other test centre.]	Any valid reason relating to the test statistic.	dB1
			[2] **12**

Expd	***A***	***B***	***C***	**Total**
Pass	92.482...	100.970...	83.546...	277
Fail	114.517...	125.029...	103.453...	343
Total	207	226	187	620

Observed	Expected	$\frac{(O-E)^2}{E}$	$\frac{O^2}{E}$
99	92.48	0.4596...	105.9796...
110	100.97	0.8075...	119.8375...
68	83.55	2.8941...	55.3441...
108	114.52	0.3712...	101.8512...
116	125.03	0.6521...	107.6221...
119	103.45	2.3373...	136.8873...
	Totals	7.522	627.522...

Question Number	Scheme		Marks
4. (a)	$\bar{x} = 230.5$; 95% confidence limits for μ are		
	$230.5 \pm 1.96 \times \frac{1.2}{\sqrt{5}}$	their $\bar{x} \pm z \times \frac{1.2}{\sqrt{5}}$	M1
		$z = 1.96$	B1
	$= (229.44815..., 231.55185...) = \text{awrt}(229.4,\ 231.6)$	At least one end-point is correct.	A1
		Both end-points are correct.	A1
			[4]
(b)	{ Let X = number of confidence intervals that ***don't contain*** μ }	{ Let Y = number of confidence intervals that ***contain*** μ }	
	$\{\text{So } X \sim\}\text{B}(20, 0.05)$	$\{\text{So } Y \sim\}\text{B}(20, 0.95)$	M1
	$\{\text{P}(X > 3)\} = 1 - \text{P}(X \leqslant 3)$ or $1 - 0.9841$	$\text{P}(Y \leqslant 16)$	A1
		awrt **<u>0.0159</u>**	A1
			[3]
			7

Notes

4. (a)	**M1**	Allow $1.5 < \lvert z \rvert < 2$ (may be implied by one correct end point)
	B1	1.96 or better
	1st A1	either awrt 229.4 **or** awrt 231.6 (allow 229.45)
	2nd A1	both awrt 229.4 **and** awrt 231.6 (allow 229.45)
(b)	**M1**	States or applies either $X \sim \text{B}(20, 0.05)$ or $Y \sim \text{B}(20, 0.95)$
	1st A1	A correct probability statement for their distribution $1 - \text{P}(X \leqslant 3)$ or $1 - 0.9841$ **<u>or</u>** $\text{P}(Y \leqslant 16)$. Can be implied by the final answer.
	2nd A1	awrt 0.0159

Question Number	Scheme		Marks
5(a)			
	$5.84 = e^{-2.8} \times n \quad [n = 96]$		M1
	Observed (a =) 5 and Expected (b =) awrt 8.37…		A1
			(2)
(b)	H_0: Poisson(2.8) is a suitable model H_1: Poisson(2.8) is not a suitable model		B1
	For combining last two cells. Observed = 3, Expected = 6.25		M1
	$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{("5"-"8.37")^2}{"8.37"} + \frac{(3-6.25)^2}{6.25} + 9.86$		M1
	= awrt **<u>12.9</u>**		A1
	Degrees of freedom = "7" – 1 $\chi^2_{6,0.05} = 12.592$		M1 A1
	[Reject H_0] Data is not consistent with a Poisson [(2.8)] model.		A1
			(7)

		Notes
(a)	**M1**	Setting up an equation leading to a value for n. eg $\frac{e^{-2.8}(2.8)^5}{5!} n = n - 87.63$ May be implied by n = 96 (not awrt 96) or correct value of a (observed) or correct value of b (expected).
	A1	both 5 cao **and** awrt 8.37
(b)	**B1**	Both hypotheses correct. Must mention Po(2.8) at least once.
	M1	For combining last 2 cells to get observed 3 and expected 6.25 or $\frac{(3-6.25)^2}{6.25}$ seen.
	M1	For $\frac{("5"-"8.37")^2}{"8.37"} + 9.86 + ...$ or for a full method with 7 terms evaluated (condone 6 or 8 terms)
	A1	awrt 12.9 (this is dependent upon 1st M1)
	M1	Using df for their number of cells – 1
	A1	12.592 (allow 14.067 from df = 8 – 1 if last 2 cells not combined or allow 11.07[0] from df = 6 – 1 if last 3 cells combined)
	A1	Jeff's model/Poisson is not suitable. Do not need to see 2.8 here. (dep on all M marks) Do not allow contradictory comments.

Question Number	Scheme	Marks
6(a)	**Label** full-time staff [1-6000] and part-time staff [1-4000]	M1
	Use random numbers to select	M1
	120 full-time staff and 80 part-time staff	A1
		(3)
(b)	Enables estimation of statistics/errors for each strata or "reduces variability" or "more representative" or "reflects population structure" **NOT more accurate**	B1
		(1)
(c)	$H_0 : \mu_f = \mu_p \quad H_1 : \mu_f \neq \mu_p$	B1
	s.e. = $\sqrt{\frac{21}{80}+\frac{19}{80}}$, $z = \frac{52-50}{\sqrt{\frac{21}{80}+\frac{19}{80}}} \left(=2\sqrt{2}\right)$	M1, M1
	= awrt **2.83**	A1
	C.V. = 2.5758 (or *p*-value awrt 0.002 (<0.005) or awrt 0.004 (<0.01))	B1
	[2.83 > 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)	$\bar{X}_f$ /Mean score for full-time staff **and** $\bar{X}_p$ /Mean score for part-time staff……	B1
	…..follow (approximate) Normal distributions.	B1
		(2)
(e)	Have assumed $s^2 = \sigma^2$ or variance of sample = variance of population for **both**	B1
		(1)
(f)	[2.53 < "2.5758"] not significant or do not reject H_0	M1
	So there is insufficient evidence of a difference in mean awareness scores	A1ft
		(2)
(g)	Training course has closed the gap between full-time and part-time staff's mean awareness.	B1 (1)
		[17 marks]

Notes

(a)	**M1**	For numbering/labelling/ordering o.e. staff in **each** group. Label all 10000 staff is M0.
	M1	For use of random numbers/random sample/random selection
	A1	(dep on either M mark) 120 full-time **and** 80 part-time
(c)	**B1**	Both hypotheses clearly labelled (allow equivalent e.g. $\mu_f - \mu_p = 0$)
	M1	Attempt at s.e. in the form $\sqrt{\frac{p}{q}+\frac{r}{s}}$ condone one number wrong
	M1	Using their s.e. in correct formula for test statistic. Must be in the form $\frac{\pm(52-50)}{\sqrt{\frac{p}{q}+\frac{r}{s}}}$
	A1	awrt 2.83 allow awrt –2.83
	B1	±2.5758 or better allow appropriate *p*-value if used consistently with correct significance level
	dM1	Dep on previous M1 for a correct statement based on their normal C.V. and their test statistic
	A1ft	For correct comment in context. Must mention "scores" or "awareness" and "types of staff".
(d)	**B1**	For mention of both means
	B1	For stating that distributions of mean(s) can be approximate normal
(f)	**M1**	For correct (ft) statement (may be implied by correct context. comment) ft C.V. from (c)
	A1ft	For correct (ft) contextualised comment with "scores" or "awareness"
(g)	**B1**	Correct comment in context that implies that there is now no (significant) difference in mean scores. Dep on significant result in part (c) and non-significant result in part (f).

Question Number	Scheme	Marks
7. (i)	$A \sim N(21, 2^2)$, $B \sim N(32, 7^2)$ and $C \sim N(45, 9^2)$ A, B, C are independent.	
(a)	$T = A + B + C$	
	$E(T) = 21 + 32 + 45\,[= 98]$ or $Var(T) = 2^2 + 7^2 + 9^2\,[= 134]$ — A fully correct method of finding $E(T)$ or $Var(T)$	M1
	$E(T) = 98$ and $Var(T) = 134$ — Both $E(A) = 98$ and $Var(A) = 134$	A1
	$\{$So $T \sim N(98, 134)\}$	
	$\{P(T > 90) = \}$ $P\left(Z > \frac{90 - "98"}{\sqrt{"134"}}\right)$ — Standardising $(\pm)$ with their mean and their standard deviation	M1
	$= P(Z > -0.69109...)$	
	$= 0.7549$ (or $0.75525...$) — awrt **<u>0.755</u>**	A1
		[4]
(b)	$\{P(A > B) = P(A - B > 0)\}$	
	$E(A - B) = 21 - 32\,[= -11]$ or $Var(T) = 2^2 + 7^2\,[= 53]$ — A fully correct method of finding $E(A - B)$ or $Var(A - B)$	M1 o.e.
	$E(A - B) = -11$ and $Var(A - B) = 53$ — Both $E(A - B) = -11$ and $Var(A - B) = 53$	A1 o.e.
	$\{$So $A - B \sim N(-11, 53)\}$	
	$\{P(A - B > 0)\} \Rightarrow P\left(Z > \frac{0 - "-11"}{\sqrt{"53"}}\right)$ — Standardising $(\pm)$ with their mean and their standard deviation	M1
	$= P(Z > 1.510966...)$	
	$= 0.06539855...$ (or 0.0655) — **<u>0.0655</u>** or awrt **<u>0.0654</u>**	A1
		[4]
(ii)	$\left\{P\left(X_1 > \bar{X} + k\sigma\right) = 0.1 \Rightarrow P\left(X_1 - \bar{X} > k\sigma\right) = 0.1\right\}$	
	$X_1 - \bar{X} = X_1 - \frac{(X_1 + X_2 + X_3 + X_4)}{4} = \frac{3X_1 - (X_2 + X_3 + X_4)}{4}$ — For writing or using $X_1 - \bar{X}$	M1
	$E(X_1 - \bar{X}) = 0$ — Correct mean for $X_1 - \bar{X}$	A1
	$Var(X_1 - \bar{X}) = \frac{9\sigma^2 + 3\sigma^2}{4^2}$ — Correct expression for $Var(X_1 - \bar{X})$	M1
	$X_1 - \bar{X} \sim N\left(0, 0.75\sigma^2\right)$ — Correct distribution for $X_1 - \bar{X}$. May be implied by standardisation	A1
	$\left\{P\left(X_1 - \bar{X} > k\sigma\right) = 0.1 \Rightarrow P\left(Z > \frac{k\sigma - 0}{\sqrt{0.75\sigma^2}}\right) = 0.1\right\}$	
	So, $\frac{k}{\sqrt{0.75}} = 1.2816$ — Standardising with their $Var(X_1 - \bar{X})$ (must be in terms of σ^2). Note that σ must cancel.	M1
	1.2816 or better	B1
	$\left\{k = \sqrt{0.75}\,(1.2816)\right\} \Rightarrow k = 1.109898157...$ — Dep on all previous M marks for awrt **<u>1.11</u>**	A1
		[7]
		15