GCE

Further Mathematics A

Y532/01: Statistics

AS Level

Mark Scheme for June 2024

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. **Annotations**

Annotation	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

5. **Subject Specific Marking Instructions**

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c. The following types of marks are available.

M
A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words "Determine" or "Show that", or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep*' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
   - When a value is **given** in the paper only accept an answer correct to at least as many significant figures as the given value.
   - When a value is **not given** in the paper accept any answer that agrees with the correct value to **3 s.f.** unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
     NB for Specification B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads "2 s.f".

   Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
   Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g. Rules for replaced work and multiple attempts:
   - If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
   - If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
   - if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors. If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold "In this question you must show detailed reasoning", or the command words "Show" or "Determine". Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question		Answer	Marks	AO	Guidance
1	(a)	4	B1 [1]	1.1	Exact, allow 4.00
	(b)	$4\times\text{Var}(W)$ or $\Sigma 4w^2\text{P}(w) - 4^2$	M1	1.1	Can be implied by answer.
		$\frac{8}{3}$	A1 [2]	1.1	Can be written down, exact or awrt 2.67
	(c)	$4 + k = \frac{8}{3}$	M1	3.1a	Use *their* **(a)** + k = *their* **(b)**
		$k = -\frac{4}{3}$	A1 [2]	1.1	Exact or awrt –1.33
	(d)	$\Sigma s^2\text{P}(s)$ (= 18)	M1	1.1	Clear attempt at finding $\Sigma s^2\text{P}(s)$
		$18 - 4^2$	M1	1.1	Subtract 4^2
		2	A1 [3]	1.1	Exact, allow 2.00 Can scale variables, e.g. $X = S - 3$: $\text{E}(X^2) = \frac{18}{9} = 2$; $\text{E}(X) = 0$; $\text{Var}(S) = 2$

Question		Answer	Marks	AO	Guidance
2	(a)	H_0: there is no association between grade and method of transport, H_1: there is association	B1 [1]	1.1	Needs context. Allow "relationship", but *not* "correlation"; allow "grade and method are independent/dependent"; *not* "insufficient evidence that there is association …" etc. Can be recovered from later part
	(b)	Expected frequency is 64×100/160 (= 40)	M1	1.1	Clear method for expected frequency, allow without working only if at least two other expected frequencies shown correctly 6.3 11.2 10.5 22.5 40 37.5 7.2 12.8 12
		$(43 - 40)^2/40$	M1	1.1	Clear indication of $(O - E)^2/E$ used
		= 0.225 **AG**	A1 [3]	1.1	Correctly obtain AG 0.225, needs both previous marks
	(c)	$\Sigma x^2 = 9.69$	B1	3.3	Awrt 9.69
		> 9.488	B1	1.1	Explicit comparison with 9.488
		Reject H_0. There is significant evidence of association between grade and method of transport	B1ft [3]	2.2b	Contextualised, not over-assertive. FT on their TS but *not* on wrong 9.488; *not* FT from reversed hypotheses. "Reject H_0" can be equivalent, e.g. "Accept H_1", or omitted. *Allow* "evidence that grade and method are dependent", but *not* "significant evidence that grade is dependent upon method of transport" (or vice versa). *Not* "insufficient evidence of no association", *not* "sufficient evidence that there may be association"
	(d)	Grade C/walk-or-cycle, as biggest contribution to TS	B1 [1]	3.4	Correct combination identified, and correct justification needed, but don't need to state 2.006. *Not* with wrong reason, e.g. "as this is closest to critical value" or "biggest difference between O and E"

Question		Answer	Marks	AO	Guidance
3	(a)	0.836 (0.835657)	B2 [2]	1.1 1.1	Allow [0.835, 0.836]. If B0, allow B1 if two of 366, 0.0402, 3.21 or two of 5494(.38), 0.604, 48.14 seen, or correct substitution into formula
	(b)	$t = 0.135 + 0.00876x$ or $t = 0.135 + \frac{2407}{274720}x$	B2 [2]	1.1 1.1	*a*: awrt 0.135. *b*: exact or in range [0.0087, 0.0088]. Needs letters correct. SC: One error: B1
	(c)	The values of *a* and *b* found in **(b)** are chosen to minimise this quantity	B1 [1]	1.2	Require "minimised" OE. Allow "shows the minimised sum of squares" *Not* "sum of least squares"; *not* just "sum of squares of residuals", *not* "the lower this value, the better the line of best fit"
	(d)	0.503 (0.502897)	B1 [1]	1.1	Awrt 0.503
	(e)(i)	No effect (or *their* 0.836)	B1ft [1]	1.2	Reason not needed, ft on their **(a)**
	(e)(ii)	$t' = 1.35 + 0.0876x$	B1ft [1]	1.2	OE, e.g. "*a* and *b* multiplied by 10" or "*t* becomes *t*/10". Ignore letters. Must refer to equation, so *not* "all values ten times greater". "Increase *a* and *b* by 10": BOD B1
	(f)	Model seems to be based on people whose ages are not close to 42 *r* is quite high *or* there is quite strong correlation *or* points are likely to lie fairly close to straight line Reliability dubious, or hard to tell	B1 B1 B1 [3]	1.1 1.1 2.3	Relevant comment on 42 and data, e.g. "42 is outside the data range(s)". Allow "biased towards old and young people", allow "no one of age close to 42", but *not* "no one of age 42". *Not* "42 is in data range" Relevant comment based on value of *r*. *Not* "the value of *r* is unreliable", *not* "there is significant evidence of correlation". SC: "Data may be clumped so value of *r* is uninformative" oe: B1 Single nuanced conclusion, not inconsistent with previous comments, must have referred to both 42 and pmcc, but needs only 1 of previous 2 marks. Allow "unreliable/not reliable". *Not* "reliable" or stronger, not "slightly unreliable" Allow "probably unreliable" but *not* "might not be reliable" etc Ignore irrelevant comments, but max 2/3 if any wrong comments seen

Second B1: The data is not bivariate normal so *r* cannot be used	B0	Data may not form an ellipse	B0
Gradient is positive so correlation good	B0	PMCC might change with the inclusion of people of working age	B1

Overall:

i	PMCC changes because of large changes in age, so unreliable	B0	vi	Quite reliable: 0.835 is good correlation, and 42 is in range	B0B1B1
ii	Might not be reliable as no volunteers close to 42 and correlation is not perfect	B1B0B0	vii	Outside data range as students and old people are not 42, so despite strong correlation estimate may not be very reliable	B1B1B0
iii	0.836 implies strong positive correlation so estimate very reliable, so long as it falls in the range of recorded data	B0B1B0	viii	Strong correlation so reliable, but few results close to 42 so less reliable *[no single conclusion]*	B1B1B0
iv	Strong positive correlation so quite reliable	B0B1B0	ix	Less reliable as the data doesn't spread across all age groups, even if the value for *r* is quite strong at 0.835	B3
v	*r* would be different as the data is skewed, the two groups are unrepresentative of the whole population, so estimate unreliable	B1B0B1	x	Probably not very reliable: high correlation but few data points in the region of 42	B3

Question		Answer	Marks	AO	Guidance
4	(a)	0.168(1)	B1 [1]	1.1	Awrt 0.168. Allow $\frac{27}{8}e^{-3}$.
	(b)	$P(2 < X < 8) = 0.5649\ldots$	M1	3.3	M1A0 for 0.341 or 0.573 or 0.647 or 0.789
			A1	1.1	Awrt 0.565, can be implied
		$10\times0.565 = 5.65$	M1 [3]	3.4	10× *their* 0.565, allow rounded to nearest integer only if unrounded value seen
	(c)	$X + Y \sim \text{Po}(3 + \lambda)$	M1	3.3	Any appropriate symbol, stated or implied, allow sign errors (e.g. in next line)
		$e^{-3-\lambda}\frac{(3+\lambda)^4}{4!} = \frac{27}{8}e^{-3}\frac{3^2}{2!}e^{-\lambda}\frac{\lambda^2}{2!}$ **DR**	M1 A1	3.1a 1.1	One correct use of Poisson formula anywhere Correct equation, allow $\frac{27}{8}\times0.224\times e^{-\lambda}\frac{\lambda^2}{2!}$ or $0.378\lambda^2e^{-\lambda}$ oe
		$4(3 + \lambda)^4 = 729\lambda^2$	M1	2.1	Cancel e terms and simplify factorials, e.g. $(3 + \lambda)^4 = 182.25\lambda^2$ (correct treatment of e^{-3} can be implied by correct solutions to equation)
		$2(3 + \lambda)^2 = 27\lambda$ *or* $4\lambda^4 + 48\lambda^3 - 513\lambda^2 + 432\lambda + 324 = 0$	M1	1.1	Take square root, allow ignoring of negatives, and find at least one solution to quadratic *or* multiply out to obtain quartic *and solve 5-term equation*
		No need to consider other sign as $\lambda > 0$	B1	2.3	Explicit reason for rejection of – sign or of negative solutions to quartic (other solutions are $-\frac{3}{4}(13\pm3\sqrt{17}) = -0.473$ or -19.027)
		$2\lambda^2 - 15\lambda + 18 = 0 \Rightarrow \lambda = 6$ or $\frac{3}{2}$	B1 [7]	2.2a	Both solutions correct, www, no others, don't need previous B1. SC: $4(3 + \lambda)^4 = 729\lambda^2$ seen and both solutions correct but no working: (M1M1A1) M0B0B1 SC: both correct solutions and reject two other solutions that are *wrong*: loses penultimate B1 only (max 6/7)
	(d)	In using $X + Y \sim \text{Po}(3 + \lambda)$	B1 [1]	3.5b	Allow $\text{Po}(X + Y) = \text{Po}(X) + \text{Po}(Y)$, or $P(X + Y = 4)$, but *not* $E(X + Y) = E(X) + E(Y)$, *nor* $P(X + Y = 4) = P(X = 4) \times P(Y = 4)$, *nor* "when adding parameters". "When doing $P(X + Y)$ assumed the probability of one not affecting other": B1 Any wrong statement seen: B0

Question		Answer	Marks	AO	Guidance
5	(a)	H_0: $\rho_s = 0$, H_1: $\rho_s > 0$, where ρ_s is the population srcc	B2	1.1 2.5	Allow r or ρ. One error, e.g. 2-tailed, or symbol not defined in terms of population, or at all: B1 "H_0: no association between marks given by judges, H_1: positive association": B2. "Positive" omitted: B1. Allow "positive correlation" or "agreement", but "Judges agree/do not agree with each another": B1
		$0.964 > 0.8929$	B1	1.1	Explicit comparison with 0.893 or better, allow $\frac{27}{28} > 0.893$
		Reject H_0. There is significant evidence that judges agree with each other.	B1 [4]	2.2b	Full conclusion, contextualised, not over-assertive, needs 0.893 or 0.929. "Reject H_0" can be equivalent or omitted. Don't need "positive" in conclusion. *Not* "insufficient evidence of no association". *Not* "sufficient evidence that the judges' ranks are positively correlated" 2-tailed (0.964 > 0.9286): can give B1B0 B0 B1, max 2/4
	(b)	$1-\frac{6\Sigma d^2}{7\times 48}=\frac{27}{28}$	M1	2.1	Equation using correct Spearman formula seen, *not* using $(86 - x)^2$
		$\Rightarrow \Sigma d^2 = 2$	A1	1.1	Correctly obtain $\Sigma d^2 = 2$
		Only one pair in wrong order	B1	3.1b	Stated or implied, e.g. any number in range [81, 90] mentioned
		$\Rightarrow 82 \le X \le 89$ $(81 < X < 90)$	A1 [4]	2.2a	Or equivalent (allow non-integer answers) Not ranked (typically considering $[86 - x]^2$): 0 SC 27/28 not used: B2 for final answer only
	(c)	e.g. (If it is valid, it is better because) the PMCC takes into account the actual scores *or* the data may have a bivariate normal distribution *or* PMCC measures correlation, not association/ranking	B1 [1]	1.1	Allow "uses scores, not ranks", but *not* "because the data are scores, not ranks". *Not* "data is bivariate normal", *not* "PMCC takes into account whether the two judges' scores are very different" More than one reason, one of which is wrong: B0

Exemplars:

i	The ranks might be close but the judges might still not agree with each other as the scores might be very different *[but they aren't …]*	B0
ii	To determine if there is linear correlation, i.e. if they gave similar marks to the same people rather than just giving higher marks to some and lower to others	B1 isw
iii	Marks are quantitative variables whereas ranks are usually given to qualitative variables	B0
iv	PMCC works better for scores than for rankings	B0
v	To show how similarly they score each contestant *[PMCC is unaffected by linear scaling]*	B0
vi	PMCC used quantitative values whereas rankings can be subjective	B1

Question		Answer	Marks	AO	Guidance
6	(a)	Whether or not one car is white is independent of whether or not any other is. For any car, the probability that it is white is constant.	B1 B1 [2]	1.1 1.1	Independence, *or* "selected randomly", stated, context used. Allow BOD in application of context, e.g. "probabilities of white cars are independent" p constant, oe, stated, in context *Not* "singly". More than 2 conditions: max B1
	OR	The sample is a random sample of residents	**B2**		"Selected randomly": B1 only
	(b)	0.9^6 $= 0.531(441)$	**M1** **A1** **[2]**	1.1 1.1	$0.9^7 = 0.478...$ or $0.9^5 = 0.590$: M1A0. *Not* $1 - 0.9^6$. *Not* $1 - 0.1(1 + 0.9 + ... + 0.9^5)$ unless answer correct. Clearly correct numerical answer, in range [0.532, 0.532], www
	(c)	$\mathrm{E}(Y) = \frac{1}{p} - 1$ and $\mathrm{Var}(Y) = \frac{1-p}{p^2}$ Hence $\mathrm{E}(Y) \div \mathrm{Var}(Y) = p$.	**M1** **B1** **A1** **[3]**	3.1b 1.1 1.1	$Y = X - 1$ stated or implied Correct variance formula, allow if unclear as to whether it applies to X or Y CWO, needs to be simplified to p only. Typically, $\frac{1}{p} \div \frac{1-p}{p^2} = \frac{p}{1-p}$: M0B1A0
	(d)	$\frac{1}{2}p(1-\frac{1}{2}p)^2 = kp(1-p)^2$ $2k = \left(\frac{1-\frac{1}{2}p}{1-p}\right)^2$ or $8k = \left(\frac{2-p}{1-p}\right)^2$ oe	**M1** **A1**	3.1a 2.1	Equation with at least one geometric formula correct in terms of p or $\frac{1}{2}p$ Correct equation with p cancelled, aef, can be implied by correct k etc
		$\frac{1}{2}p < p \Rightarrow 1 - \frac{1}{2}p > 1 - p$ $\Rightarrow$ LHS > 1 $\Rightarrow k > \frac{1}{2}$	**B1** **B1** **B1** **[5]**	2.4 2.2a 3.2a	Reason for linear inequality for p, e.g. LHS > 1 Independent but needs justification Final answer $k > \frac{1}{2}$ or $k > 0.5$ only. *Not* $k \geq 0.5$.
	OR	$p = 0$, $k = 0.5$ $p > 0$, $k > 0.5$ (and k increases with p because $1 - \frac{1}{2}p > 1 - p$) $k > 0.5$	**M1** **B1** **B1**		Use one value of p in range [0, 1) to find a value of k Assert k increasing with p, allow "$k \to \infty$ as $p \to 1$" (rigorous reason not needed) Final answer, $k > \frac{1}{2}$ or $k > 0.5$ only. *Not* $k \geq 0.5$.
	OR	$p = \frac{8k - 2 \pm \sqrt{8k}}{8k - 1}$ and $0 < p < 1$ Ignore negative sign (inequalities satisfied for all k) $k > 0.5$	**M1** **B1** **A1**		Solve quadratic for p and use at least one correct inequality for p, allow non-strict inequalities Correct choice of signs Final answer, $k > \frac{1}{2}$ or $k > 0.5$ only. *Not* $k \geq 0.5$.
	NB:	Attempted use of $b^2 - 4ac$ can get first M1A1 but then 0			Max 2 (this leads nowhere as it does not consider $0 < p < 1$)

p	k
0	0.5
0.1	0.557
0.2	0.633
0.3	0.737
0.4	0.889
0.5	1.125
0.6	1.53
0.7	2.35
0.8	4.5
0.9	15.125
1	infinity

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