GCE

Further Mathematics A

Y542/01: Statistics

A 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	Marks	Guidance
1	(a)	$b + 2c + 0.3 = 1.25$	M1	1.1	M1	Use $\Sigma xp = 1.25$, e.g. $b + 2c = 0.95$
		$E(X^2) = 0.8875 + 1.25^2$ (= 2.45) $b + 4c + 0.9 = 2.45$	M1 M1	1.1 1.1	M1 M1	Use $\text{Var}(X) = \Sigma x^2 p - 1.25^2$ (*not* – 1.25 or $+1.25^2$) Use $\Sigma x^2 p$ = their 2.45 to obtain equation, e.g. $b + 4c$ = constant (1.55), allow from –1.25 or $+1.25^2$
	OR	$(-1.25)^2 a + 0.25^2 b + 0.75^2 c + 0.1 \times 1.75^2 = 0.8875$ $1.5626a + 0.0625b + 0.5625c = 0.58125$	M1 A1		M1 A1	Clear use of $\Sigma(x - 1.25)^2 p(x)$ AEF, e.g. $\frac{25}{16}a + \frac{1}{16}b + \frac{9}{16}c = \frac{93}{160}$. Can be implied by correct answers
		$b = 0.35$, $c = 0.3$ $a = 0.25$	A1 B1ft **[5]**	1.1 1.1	A1 B1ft **[5]**	Both correct, exact only (e.g. $\frac{7}{20}, \frac{3}{10}$) 0.9 – *their* $(b + c)$, needs $0 \leq a \leq 0.9$.
	(b)	$4\text{Var}(X) = 3.55$	B1 **[1]**	1.1	B1 **[1]**	3.55 or $3\frac{11}{20} = \frac{71}{20}$, exact
	(c)	B(20, 0.1) $npq = 1.8$	M1 A1 **[2]**	3.3 1.1	M1 A1 **[2]**	Stated or implied as main method, e.g. by correct answer or by $np = 2$ with no wrong working anywhere, *not* isw 1.8 or exact equivalent only, as final answer (17.75 etc is M0A0 even if $0.1 \times 20 = 2$ seen)

Question		Answer	Marks	AO	Guidance
2	**(a)**	0.401 (0.400863)	**B2** **[2]**	1.1 1.1	Awrt 0.401. SC: If B0, give B1 for any two of 54.75, 173.4, 39.06 *or* any two of 876, 2775, 625 seen, *or* for answer 0.4(00)
	(b)	Points do not lie very close to a (straight) line	**B1** **[1]**	2.4	OE, e.g. "moderately scattered" or "vaguely linear". Must be in terms of diagram, *not* e.g. "weak correlation". *Not* "not very close together", *not* "weak gradient", *not just* "positively correlated". Ignore comments about ellipses or bivariate normal. Allow sketch if reasonably appropriate. No wrong extras, e.g. "through origin".
	(c)	H_0: $\rho = 0$, H_1: $\rho > 0$, where ρ is the population pmcc between student's height and dog's height *or* H_0: no correlation between dog owner's height and dog's height, H_1: positive correlation (B1 if "positive" omitted)	**B2**	1.1 2.5	Allow ρ defined in terms of *either* population *or* context (or both). Allow H_0: $\rho \leq 0$. Allow r. Needs "coefficient" or "pmcc" oe One error, e.g. two-tailed, or ρ not defined as above: B1. H_0: taller dog owners do not have taller dogs, H_1: taller dog owners have taller dogs: B1. Allow "association", allow "independent" (but needs 1-tail for B2)
		CV 0.4259 or $p = 0.0619(32)$	**B1**	1.1	Either, for p allow awrt 0.062. (Two-tailed CV 0.4973 is B0 here)
		$0.401 < 0.4259$ or $0.062 > 0.05$ so do not reject H_0	**M1ft**	1.1	FT on their r if $0 < r < 1$, and FT from 0.4973 but no other CV. Needs like-with-like.
		Insufficient evidence that there is (positive) correlation between student height and dog shoulder height	**A1ft** **[5]**	2.2b	Contextualised, acknowledge uncertainty; *not* "there is evidence that there is not positive correlation". Don't need "positive" here (2-tailed test typically B1B0, B0, M1A1)
	(d)	Different as shoulder height → weight not a linear transformation, or "probably similar as taller dogs weigh more", etc	**B1** **[1]**	2.3	"Yes", "Different", "not very different", "little difference", "similar" but no stronger, or "unclear", with reason based on a (positive) relationship between height and weight of dogs; nothing completely wrong seen. *Not* "No", "unlikely", "probably not different", "little to no difference", etc. *Not* relationship between owners and weights.

Exemplars for 2(c):

Hypotheses:

Their hypotheses	Comment	Mark
H_0: $\rho = 0$, H_1: $\rho > 0$, where ρ is the population pmcc	Correct	B2
H_0: $r = 0$, H_1: $r > 0$, where r is the pmcc between heights of students and dogs	Correct, allow r	B2
H_0: $\rho = 0$, H_1: $\rho > 0$, where ρ is the pmcc	Both "population" and context omitted	B1
H_0: $\rho = 0$, H_1: $\rho \neq 0$, where ρ is the pmcc	Two errors	B0
H_0: no correlation between dog owner's height and dog's height, H_1: positive correlation	Correct	B2
H_0: no correlation between dog owner's height and dog's height, H_1: there is correlation	"Positive" omitted	B1
H_0: taller dog owners do not have taller dogs, H_1: taller dog owners have taller dogs	As on MS	B1
H_0: dog owner's height and dog's height independent, H_1: not independent	Allow this	B2

Comparisons:

0.401 > 0.05 (not "like-with-like"), B0 and then M0A0. Any CV other than 0.4259 (0.426) or 0.497(3) used: B0M0A0.

Conclusions:

Their conclusion	Comments	Mark
Accept H_0. Insufficient evidence of correlation between heights	Correct, allow "accept H_0".	M1A1
There is insufficient evidence of correlation [Condone omission of "do not reject H_0"]	No context.	M1A0
Do not reject H_0. There is significant evidence that there is no correlation between the heights	Wrong	M1A0
Do not reject H_0. The mean reading age is 10.75 in this district	Too assertive	M1A0
There is insufficient evidence to reject H_0. Taller students do not have taller dogs	BOD	M1A1

2(d):

Unlikely as this is linear coding	B0
Unlikely as weight is proportional to height	B0
No as taller dogs have greater weight	B0
Not likely to be different: weight is just as random as height	B0
Probably, because taller owners probably have heavier dogs	B0
Little to no difference as weight has some dependence on height, so this is linear coding	B0
Probably be different, as heavier dogs need stronger owners	B0

Quite similar because height & weight are correlated	B1
Would be similar as tall dogs are heavier but hard to tell	B1
Weight proportional to height^3 so PMCC would be larger	B1
Probably not very different as tall dogs weigh more	B1
Height & weight correlated so r similar but weaker	B1
Not much different as weight is often proportional to height	B1
Unclear as weight and height are correlated but hard to tell	B1

Question		Answer	Marks	AO	Guidance
3	(a)	H_0: $\mu = 10.75$, H_1: $\mu \neq 10.75$, where μ is the population mean reading age in the district *Or:* H_0: The mean reading age is 10.75, H_1: The mean reading age is not 10.75	**B2**	1.1 2.5	Allow μ defined in terms of population *or* context. SC: One error, e.g. μ not defined (at all), or one-tailed, B1, *but* $\bar{x}$ or 11.16(25) used in hypotheses: B0
		$\bar{x} = 11.16(25)$	**B1**	1.1	Stated or implied, allow 11.2 or better
		$\hat{\sigma}^2 = 3.78(3386)$ or $\hat{\sigma} = 1.945$	**B2**	1.1 1.1	Allow B1 for 3.736 or 3.74… or 1.93(28…). Can be implied. B1B0 can be implied by $p = 0.0281$ or $z = 1.91$. Second B1 can be allowed if multiplier 80/79 seen anywhere.
		$z = \frac{(11.1625 - 10.75)}{\sqrt{3.783386/80}}$	**M1**	3.3	Evidence of standardisation using 80, e.g. $p = 0.0281$, allow square root errors only if algebraic evidence seen, allow signs reversed. *Not* N(11.1625, …) stated (but can get last M1A1)
		$p = 0.0289$ *or* $p = 0.05785$ (if 0.05 used) *or* $z = 1.897$	**A1**	3.4	Awrt 0.029. Or $p = 0.03075$ from t_{79}, or 0.0615 if compared with 0.05. (Biased estimate gives $p = 0.0281$, $z = 1.91$: M1A0 here.) If continuity correction used, can get M1A0 and final M1A1.
		$z < 1.96$ *or* $p > 0.025$ *or* 0.05 as appropriate	**B1**	1.1	0.025 or 0.05 or 1.96 used for like-with-like comparison
	or:	$10.75 + z\sqrt{(3.783/80)}$	**M1**		Recognisable z and 80 used, ignore LH CV (= 10.323), allow √ errors, *their s* (warning: $\hat{\sigma} = 1.945$ is very close to 1.96)
		$z = 1.96$	**B1**		Stated or implied, allow from wrong tail
		$11.16 < 11.176$	**A1ft**		FT on their z, e.g. 11.105 from $z = 1.645$ (conclusion reverses) SC: CV $11.16 - 1.96\sqrt{(3.783/80)} < 10.75$, M0B1A0, M1A1
		Do not reject H_0. There is insufficient evidence that the mean reading age is not 10.75 in this district	**M1ft** **A1ft** **[10]**	1.1 2.2b	FT on their z, needs 80 used, needs like-with-like comparison, allow from comparing ½p with 0.05 Contextualised, not over-assertive, needs double negative oe
	(b)	The central limit theorem allows assumption that the distribution of the sample mean is (approximately) normal.	**B1** **[1]**	1.2	Must refer to sample mean [*not* "it", or just "sample"] or $\bar{X}$ or $\bar{x}$, or "distribution of means" oe.

Exemplars for 3(a):

Hypotheses:

Their hypotheses	Comments	Mark
H_0: $\mu = 10.75$, H_1: $\mu \neq 10.75$, where μ is the population mean reading age	Correct	B2
H_0: $\mu = 10.75$, H_i: $\mu \neq 10.75$, where μ is the mean reading age	OK: μ defined in context	B2
H_0: $\mu = 10.75$, H_i: $\mu \neq 10.75$, where μ is the population mean	OK: μ defined using "population"	B2
H_0: $\mu = 10.75$, H_1: $\mu \neq 10.75$, where μ is the mean	μ not defined in context *or* "population"	B1
H_0: $\mu = 10.75$, H_1: $\mu > 10.75$	Two errors: one-tailed, μ not defined (at all)	B0
H_0: The mean reading age is 10.75, H_1: The mean reading age is not 10.75	OK	B2
H_0: The average reading age is 10.75. H_1: The average reading age is not 10.75	Not "mean"	B1
H_0: There is no change in the mean reading age, H_1: there is change	As in MS	B1
H_0: There is no evidence that the mean reading age is not 10.75, etc	"evidence" does not belong in hypotheses	B1

Calculations (assuming no other evidence of using correct formula for z):

Their calculation	Comments	Mark	Can get last M1A1?
$z = 1.90$ or $p = 0.0289$	Correct	Full marks	Yes
$p = 0.0578(5) > 0.05$	Correct	Full marks if compared with 0.05	Yes
$z = 1.91$ or $p = 0.0281$	Biased σ used	(Preceding B1 not B2) then M1A0	Yes
$p = 0.0563 > 0.05$	Biased σ used	(Preceding B1 not B2) then M1A0 if compared with 0.05	Yes
$z = 0.2134$ or 0.212, or $p = 0.4155$ or 0.416	Divisor 80 omitted	M0A0	No
Other values of z or p	M0A0 unless they show evidence of using $\sigma/\sqrt{80}$ or $\sigma^2/\sqrt{80}$ or $\sigma^2/80$ or $\sigma/80$, in which case they can get M1A0		No unless evidence as in previous column, in which case yes
CV $10.75 - 1.96\times0.217$ $11.16 > 10.32$	Wrong tail of $10.75 \pm z\sqrt{(s^2/80)}$	M0 B1 A0	No
$10.75 + 1.645\times0.217$ $11.16 > 11.11$	1.645 wrong	M1 B0 A1 (ft on 1.645)	Yes (Conclusion reversed: Reject H_0, etc.)
$11.1625 - 1.96\times0.217$ $10.737 < 10.75$	Centred on 11.1625 and not 10.75	M0B1A0	Yes

Comparisons:

Their comparison	Comments	Mark	Can get last M1A1?
1.91 < 1.96	Correct comparison, wrong *z*	B1	Yes
0.0579 > 0.05	Correct	B1	Yes
0.0281 > 0.025	Correct comparison, wrong *p*	B1	Yes
0.0289 < 0.05	Wrong	B0	Yes, conclusion reverses
0.9711 < 0.975	Correct	B1	Yes
0.0289 < 0.975	Wrong tail	B0	No
0.0579 < 1.96	Not like-with-like	B0	No

Conclusions:

Their conclusion	Comments	Mark
Accept H_0. There is insufficient evidence that reading age is not 10.75	Correct, allow "accept H_0".	M1A1
There is insufficient evidence to reject H_0. The reading age is 10.75	BOD	M1A1
Accept H_0. There is insufficient evidence that reading age has changed	BOD	M1A1
There is insufficient evidence that the average is not 10.75	No context. Condone omission of "do not reject H_0"	M1A0
Do not reject H_0. There is significant evidence that the mean age is 10.75	Wrong	M1A0
Do not reject H_0. The mean reading age is 10.75 in this district	Too assertive	M1A0

Question		Answer	Marks	AO	Guidance
4	(a)	792	B1 [1]	1.1	Allow $^{12}C_5$
	(b)	0.02×792 (= 15.84) *or* 12/792 = 0.01551…, 19/792 = 0.0239…	M1	3.4	Find 2% of *their* **(a)**, *or* any one CF (> 1) ÷ *their* **(a)**. (*Not* 59) (18 or 20 are in tables and do not imply M1 unless clear evidence)
		0.0155 < 0.02 < 0.0239 so critical region is $(15 \leq S) \leq 19$	A1 [2]	2.2a	Correct inequality from at least one correct relevant calculation. Allow "$S \leq 19$", or just "≤ 19". *Not* "CV = 19". SC: ≤ 19 with no working involving their 792: M0.
	(c)	$\frac{1}{2}n(m+n+1) = 200$, $\frac{1}{12}mn(m+n+1) = 616\frac{2}{3}$	B1	2.1	Both correct, stated or used.
		Divide: $\frac{1}{6}n = \frac{37}{12} \Rightarrow n = 18.5$ $(m = 12.5)$	B1*	3.1a	Solve to get one correct answer, e.g. 7400/400, needs both previous equations but allow if one constant wrong
		$\Rightarrow n$ not an integer, hence impossible	depB1 [3]	2.4	Valid reason for impossible, allow "can't be a decimal" etc, needs both previous B1s, cwo

Question		Answer	Marks	AO	Guidance
5	(a)	Bursts occur independently of one another ...	B1	3.3	Allow "probabilities of bursts must be independent". *Not* "number in one interval independent of number in another."
		and at constant average rate *or* at a uniform rate	B1 [2]	3.3	*Not* "constant probability", *not* "constant <u>rate</u>", *not* "average constant rate", *not* "mean ≈ variance". B0B0 unless at least one contextualised. Ignore "singly", but otherwise if more than 2 given, max B1
	(b)	These are not very close together ... so a Poisson distribution may not be valid *(Ignore "mean = variance for (exact) Poisson")*	M1 A1 [2]	2.2b 1.2	Comment on closeness (*not* on equality) Inference, not too definite (i.e., *not* "not valid"). "In Poisson they're the same but here they're different" M0
	(c)	H_0: *N* has (follows) a Poisson distribution H_1: *N* does not have a Poisson distribution	B1 [1]	1.1	Allow H_0: "Poisson is a good model", "data can be modelled by …", "data consistent with Poisson", "data follows/fits Poisson", "supports", but *not* "there is evidence that …" *Not* Poisson(3.55).
	(d)	$E_f(3) = 60\times P(3) = 12.85$ $(8 - 12.85)^2/12.85$ $= 1.83(1207)$	B1 M1 A1 [3]	3.1a 1.1 1.1	E_f in range [12.8, 12.9], can be inferred from answer $(8 - \textit{their}\ E_f)^2/\textit{their}\ E_f$ needed if answer not correct Awrt 1.83
	(e)	9.202 < 9.488 Do not reject H_0. There is insufficient evidence that the number of bursts of song in 5-minute periods does not have a Poisson distribution	B1 M1ft A1ft [3]	1.1 1.1 2.2b	Compare *their* 9.202 with 9.488 (wrong 9.202 loses no marks) Allow for comparison with 11.07 or 12.59, or, with reversed conclusion, 7.815. FT on *their* 9.202 Contextualised *or N*, not too assertive, FT on *their* 9.202. Needs double negative, *not* "can be modelled by …" etc. Condone "Po(3.55)" here.
	(f)	It affects the validity as it suggests that bursts are not independent (as if one burst is heard it is more likely that another will be)	B1 [1]	3.2a	"Yes" or "less valid" or "not valid" oe, and reason in context. *Allow* "bursts are not independent" or "not random" . *Not* "*N* is not independent", *nor* "not singly".

Question		Answer	Marks	AO	Guidance
6	(a)	$[({}^6C_2 \times 5) + {}^6C_3] \div {}^{11}C_3$ $[= (15\times5 + 20) \div 165]$ *or* $\frac{6}{11}\times\frac{5}{10}\times\frac{5}{9}\times3+\frac{6}{11}\times\frac{5}{10}\times\frac{4}{9}$, *or* $1-\frac{{}^5C_3+{}^5C_2\times6}{{}^{11}C_3}$	M1	2.1	One term omitted from quotient (e.g. $\frac{5}{11}$ = 0.455 or $\frac{7}{33}$ = 0.212 or $\frac{7}{11}$ = 0.636 or $\frac{29}{33}$ = 0.879), or one number from product, (e.g. $\frac{3}{11}$ = 0.273): M1A0
		= $\frac{19}{33}$ or 0.5757...	A1 [2]	1.1	Exact or 0.576 or better Other methods: Correct answer B2, else 0
	(b)	$7 \div {}^{11}C_5$ $[= 7 \div 462]$	M1	1.1	Or $\frac{5}{11}\times\frac{4}{10}\times\frac{3}{9}\times\frac{2}{8}\times\frac{1}{7}\times7$ (must have 6 or 7) $6 \div {}^{11}C_5$ (= $\frac{1}{77}$ = 0.0130) or $7 \div {}^{11}P_5$: M1A0
		= $\frac{1}{66}$ or 0.01515...	A1 [2]	2.2a	Exact or 0.015 or better, www Other methods: Correct answer B2, else 0
	(c)	${}^7C_5 \div {}^{11}C_5$ $[= 21 \div 462]$	M1	3.1b	Either correct term seen, e.g. (5!6!)/11!
			A1	1.1	Fully correct expression
		= $\frac{1}{22}$ or 0.04545...	A1 [3]	2.2a	Exact or 0.045 or better, www Other methods: Correct answer B3, else 0
	(d)	$7 \times {}^6C_2 \div {}^{11}C_5$	M1	3.1b	${}^7P_2$, ${}^7C_2$, ${}^6C_2$, ${}^6P_2$ *or* ${}^7C_3$ in numerator, e.g. 7×6×5 or 6×5×4 (e.g. $\frac{1}{11}$, $\frac{1}{22}$, $\frac{5}{154}$, $\frac{5}{11}$, $\frac{5}{66}$) or $\frac{5}{66}$ *or* diagram showing 6 blues and 7 gaps: M1
			A1	1.1	Numerator correct
		= $\frac{5}{22}$ or 0.227272...	A1 [3]	2.2a	Exact or 0.227 or better Other methods: Correct answer B3, else 0
	(e)	No because numerator and denominator would both be multiplied by 5! [factor needn't be present or correct] *or* No as we are concerned only about the colour, OE	B1 [1]	2.4	No with relevant reason that is not wrong, e.g. "it makes no difference that they now have labels". More than 1 reason: OK unless one is wrong

Exemplars for 6(e):

Not changed as you still treat them as yellow	B1
Different ways of arranging counters does not affect probability	B1
Not changed as being yellow is independent of numbers	B1
No as do not require a specific order of yellows or blues	B1
No as still 5 yellow counters to choose from	B1
No as it is only the colour that matters	B1
Both top and bottom are × same number so unchanged	B1
No as we use permutations not combinations	B1
No because still the same number of possibilities	B1
"No", no reason	B0

Question		Answer	Marks	AO	Guidance
7	(a)(i)	(Squares are ≥ 0 so the expression is minimised by) making both squared brackets zero	B1 [1]	2.1	Needs "makes both brackets zero" oe, don't need "squares" or "minimised" here
	(a)(ii)	This choice of a and b gives the minimum (sum of) squares of residues	B1 [1]	1.2	OE. Needs "minimises" oe *and* "squares of residuals/ differences/distances/errors" oe, but don't need "sum of"
	(b)	Dependent, response	B1 [1]	1.2	Both, no others
	(c)	$\frac{314}{21}$ or 15.0 (14.952)	B1 [1]	1.1	Exact or in range [14.9, 15.0] Allow 15 only if 3SF seen correct in working.
	(d)	(8) must be within the range of the given data, or "must be interpolation" or "not extrapolation".	B1 [1]	2.3	Allow "within range of data". *Not* "within range of y-values", *not* "must be one of the data values". Ignore extra comments, except that if anything definitely wrong seen: B0
	(e)	$x = \frac{1}{4}(u-2), y = \frac{1}{2}(8-v)$ $\frac{1}{2}(8-v) = -\frac{6}{7} + \frac{83}{42} \times \frac{1}{4}(u-2)$	M1 M1	3.1a 1.1	Rearrange Substitute into equation
	OR	Gradient of v on u = (gradient of y on x) × –2 ÷ 4	M1A1		Use $\frac{dv}{du} = \frac{dy}{dx} \times \frac{dv}{dy} \div \frac{du}{dx}$ or equivalent, e.g. $b' = S_{uv} / S_{uu} = (S_{xy} \times (-2\times4)) / (S_{xx} \div 4^2)$
	OR	$(x, y) = (0, -\frac{6}{7}), (\frac{36}{83}, 0)$; $(u, v) = (2, \frac{68}{7}), (\frac{310}{83}, 8)$ New gradient is $(\frac{68}{7} - 8) \div (2 - \frac{310}{83})$	M1 M1		Find any 2 points on (y on x) and convert to (u, v) Find new gradient
	OR	$v = a + bu \Rightarrow 8 - 2y = a + b(2 + 4x)$ Compare coefficients of x: $4b \div (-2) = \frac{83}{42}$	M1 A1		Substitute *and* compare coefficients of x 4 and –2 correctly placed
		Gradient is $-\frac{83}{84}$ (which is very close to –1, **AG**)	A1 [3]	3.2a	Obtain –0.988 or better. Ignore intercept constants. Don't need conclusion.

Question		Answer	Marks	AO	Guidance
8	(a)	**DR:** $\bar{t} = 0.6188$	**B1**	1.1	Correct value of $\bar{t}$
		$E(T) = \int_0^1 t.\alpha t^{\alpha-1} dt$	**M1**	3.3	Correct integral stated or implied, correct limits somewhere.
		$= \frac{\alpha}{\alpha+1}$	**A1**	1.1	Can be by parts, giving $1 - \frac{1}{\alpha+1}$
		Choose α to make $E(T) = \bar{t}$, so $\frac{\alpha}{\alpha+1} = 0.6188$	**B1**	3.1b	Any indication that they know that $\bar{t}$ is not necessarily the same as $E(T)$, e.g. "put", mention "unbiased estimate", or use ≈ **(DR)**
		$\alpha = 0.6188\alpha + 0.6188 \Rightarrow 0.3812\alpha = 0.6188$	**M1**	3.4	Solve *their* $E(T) = 0.6188$ to find α
		$\alpha = 1.62(329)$ or $\frac{1547}{953}$	**A1** **[6]**	2.2a	Awrt 1.62 but allow 1.6 if only 2 SF given
	(b)	Probabilities are $\left(\frac{1}{3}\right)^\alpha$, $\left(\frac{2}{3}\right)^\alpha - \left(\frac{1}{3}\right)^\alpha$, $1 - \left(\frac{2}{3}\right)^\alpha$	**M1**	3.3	Correct formula for one probability, e.g. attempt at definite integral with *their* α, correct limits, *or* CDF $F(t) = t^\alpha$
		$100 \times \left(\frac{1}{3}\right)^\alpha$, $100 \times \left(\left(\frac{2}{3}\right)^\alpha - \left(\frac{1}{3}\right)^\alpha\right)$, $100 \times \left(1 - \left(\frac{2}{3}\right)^\alpha\right)$	**M1**	1.1	Multiply at least one probability by 100 *or* divide observed frequencies by 100, needs integral but allow limits confused
		16.8(07), 35.0 (34.972), 48.2(21) *or* Cumulative frequencies 16.8, 51.8 (100)	**A1**	3.4	All correct. Allow [16.8, 16.9] and awrt 35.0 and 48.2, or no 100 factor if 0.18, 0.37, 0.45 used for comparison. If CFs used, can ignore 100 (or 1)
		Reasonably close to 18, 37, 45 so a good model *or* 18, 55 (100) if CFs used	**A1ft** **[4]**	3.5a	Assessment, *not* "the model is correct" nor "the model is wrong", <u>with reason</u> (e.g. 16.8 ≈ 18, 35.0 ≈ 37, 48.2 ≈ 45) Needs all three values used (first 2 from CFD) (but they may be wrong) and both M marks, but ft conclusion from wrong α (which could lead to conclusion "not a good model").
	SC	Sample variance 0.0619, Var(T) = 0.0651, which are close; so may be good model	**M1** **A1**		Find sample variance and Var(T) & compare Conclusion as above based on these correct values. Max 2/4
		$1.4 \le \alpha \le 1.8$ gives frequencies that can be called "close". E.g.:			$\alpha = 2.62$: $E_f = 5.6, 28.9, 65.4$ which is not close; $\alpha = 1.44$ (median): $E_f = 20.6, 35.2, 44.2$ which is close

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