GCE

Further Mathematics B MEI

Y422/01: Statistics major

A Level

Mark Scheme for June 2025

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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 available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of 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. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed-Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

7. There is a NR (**No Response**) option. Award NR (No Response):

   - if there is nothing written at all in the answer space
   - 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) which is not an attempt at the question.

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

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response: Not applicable in F501
    To determine the level – start at the highest level and work down until you reach the level that matches the answer
    To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **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.

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. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)
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 2 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 A the rubric specifies 3 s.f. as standard, so this statement reads “3 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)	$P(X > 4) = \frac{1}{2} = 0.5$	B1 [1]	1.1	Accept fraction (can be uncancelled) or decimal answers throughout the question .
1	(b)	$E(X) = \frac{9}{2} = 4.5$ $Var(X) = \frac{64-1}{12}$ $= \frac{21}{4} = 5.25$	B1 M1 A1 [3]	1.1 3.3 1.1	 For attempt at $\frac{n^2-1}{12}$
1	(c)	$P(X < 4) = \frac{3}{8} = 0.375$ $= 3 \times \frac{3}{8} \times \left(\frac{1}{2}\right)^2 = 3 \times 0.375 \times 0.5^2$ $= \frac{9}{32} = 0.28125$	B1 M1 A1 [3]	1.1 3.1a 1.1	B0 if stated to be something else, eg $P(X = 2)$ For whole expression Do not allow 3! for M1 Allow their $P(X < 4)$ provided less than 0.5. Final answer must be **EXACT**

Question		Answer	Marks	AO	Guidance
2	(a)	0.1056…	B1 [1]	1.1	**BC**
2	(b)	Mean = $5 \times 20 + 5 \times 30 + 5 \times 50$	B1	1.1	For correct calculation
		Variance = $5 \times 0.8^2 + 5 \times 0.9^2 + 5 \times 1.2^2$	M1	3.3	For attempt at variance - can be implied by A1. Watch for 14.5 which comes from not squaring the SDs
		Height ~ N(500, 14.45) or N $\left(500, \frac{289}{20}\right)$	A1	1.1	For correct distribution
		So P(Height $\geq$ 495) = 0.9058…	A1 [4]	3.4	**BC** awrt 0.906
2	(c)	N$(3 \times 20 - 2 \times 30, 3.54)$	M1	3.3	For Normal and mean
		$3 \times 0.8^2 + 2 \times 0.9^2$	B1	1.1	For variance (indep)
		N(0, 3.54) so P(> 1) = 0.2975…	A1 [3]	3.4	**BC** Allow 0.297 to 0.298

Question		Answer	Marks	AO	Guidance
3	(a)	$\frac{0.5664}{\sqrt{50}}[= 0.0801]$	B1 [1]	2.1	
3	(b)	$24.721 < \mu < 25.035$	B1 [1]	1.1	Do not allow $[24.721,\ 25.035]$ Allow rounded to 2dp. What about slight error? No 11 Do not allow $24.721 < 24.878 < 25.035$
3	(c)	Confidence interval does not suggest that the mean weight of potatoes in a sack is different from 25 kg since the interval does contain 25	B1 [1]	3.4	Allow 'No (it doesn't) because interval does contain 25' or similar Do not allow statements which have no measure of doubt such as 'mean weight of potatoes is not different' Do not allow statements such as 'suggests that the mean weight of potatoes per sack is 25g'
3	(d)	Interval is given by $24.878 \pm 1.645 \times 0.0801$ $24.746 < \mu < 25.010$ So in this case the interval still contains 25 so the conclusion would be the same	 M1 B1 A1 DB1FT [4]	 3.4 1.1 1.1 2.2a	 For general form using their z-value and their 0.0801 Must use correct z-value oe Give full credit for calculation of upper limit only throughout part (d) Dependent on M1

Question		Answer	Marks	AO	Guidance
4	(a)(i)	$(\mathrm{P}(X = 5) = 0.6^4 \times 0.4 =)\ 0.05184$	B1 [1]	3.3	Allow awrt 0.0518
	(a)(ii)	$(\mathrm{P}(X > 5) = 0.6^5 =)\ 0.07776$	B1 [1]	1.1	Allow awrt 0.0778
4	(b)	Mean = 2.5 Variance = $0.6/(0.4^2) = 3.75$ Sd = $\sqrt{3.75} = 1.936$ ... Need $\mathrm{P}(1 \leq X \leq 4) = 1 - (0.6)^4$ = 0.8704	B1 B1 M1 M1 A1 [5]	3.3 1.1 1.1 3.4 1.1	 For square root of their variance For correct integer inequality from their mean and sd. Comes from $(0.564 \leq X \leq 4.436)$ Allow if on borderline – eg if sd = 2.5, then $2.5 - 2.5$ to $2.5 + 2.5$ If M0M0 allow SCB1 for correct answer. Allow awrt 0.870
4	(c)	B(20, 0.4) P(at least 5) = 1 – 0.05095… = 0.94905	B1 B1 [2]	3.3 1.1	 Allow awrt 0.949
4	(d)	4 successes first nineteen so B(19, 0.4) then × 0.4 P(fifth on 20th attempt) = 0.04665 ... × 0.4 = 0.01866…	M1 A1 [2]	3.1b 1.1	For B(19, 0.4) × 0.4 Allow if B(19, 0.4) seen and a probability multiplied by 0.4 BC If M0 allow SC1 for correct answer Allow awrt 0.0187
4	(e)	This assumption may not be valid since Gabi may get tired after practising, or they may improve as they practise more	B1 [1]	3.2b	Allow other reasonable explanations

Question		Answer	Marks	AO	Guidance
5	(a)	$\text{Var}(X) = \frac{(2-(-4))^2}{12}$	M1	1.2	For use of correct formula soi
		$= 3$	A1	1.1	
			[2]		
5	(b)	$[2\times]\frac{2}{3}\times\frac{1}{3}$	M1	3.1a	For $\frac{2}{3}\times\frac{1}{3}$
		$=\frac{4}{9}$	A1	1.1	
			[2]		

Question		Answer	Marks	AO	Guidance
6	(a)	'Boiling point' is a random variable	B1 [1]	3.3	Allow 'dependent' Do not allow 'Continuous'
6	(b)	Because this (amount of salt) is the independent variable.	B1 [1]	2.4	Allow 'Control variable' instead of 'independent variable' Allow 'Because the student is trying to find the boiling point so amount of salt should be on the x axis. Allow non-random so on *x*-axis Do not allow if subsequently contradicted
6	(c)	Amount 50 g Boiling point ≈ 101.3 Amount 200 g Boiling point ≈ 104.9	B1 B1 [2]	1.1 1.1	Allow 101, 101.26. Do not allow if given to more than 2dp Allow 105, 104.89 Do not allow if given to more than 2dp, but if both given to more than 2dp allow B0B1
6	(d)	Because the points lie very close to the line and it involves interpolation the first prediction is likely to be very reliable. The second prediction is less reliable because it involves extrapolation.	B1 B1 [2]	2.2b 3.5b	Allow 'roughly linear' or 'small residuals' in place of 'close to line' Condone 'moderately reliable' Do not allow 'The estimate lies on the regression line'
6	(e)	Resid = 101.41 – (0.0242×60+100.0486) or $= 101.41 - 101.5[006]$ $= -0.09[06]$	M1 A1 [2]	2.1 1.1	For calculation (subtraction other way around scores M1 only) SC1 for correct answer unsupported

Question		Answer	Marks	AO	Guidance
7	(a)	**DR**			
		$S_{xy} = 25.01 - \frac{1}{30} \times 2.219 \times 357.7$ [= -1.4478...]	**M1**	**1.1a**	For good attempt to find S_{xy}
		$S_{xx} = 0.2368 - \frac{1}{30} \times 2.219^2$ [= 0.072668…]	**M1**	**1.1**	For good attempt to find either S_{xx} or S_{yy}
		$S_{yy} = 4648 - \frac{1}{30} \times 357.7^2$ [= 383.02…]			
		$r = \left[\frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}}\right] = \frac{-1.4478...}{\sqrt{0.072668... \times 383.02...}}$	**M1**	**3.3**	For general form including sq. root Must see figures, not just formula
		or $\frac{-1.4478...}{\sqrt{27.833...}}$ or $\frac{-1.4478...}{5.2757...}$			
		$= -0.2744$	**A1**	**1.1**	Full marks only if answer correct and a fully correct, complete method shown Condone if given to at least 2dp providing full working shown
			[4]		
7	(b)	H_0: $\rho = 0$, H_1: $\rho \neq 0$	**B1**	**3.3**	For both hypotheses Do not allow *r* If hypotheses given in words must mention 'population' to get any credit.
		where ρ is the population pmcc between the cost of electricity and the amount of electricity being generated by wind. Allow *x* and *y*.	**B1**	**2.5**	For defining ρ in context. Do not allow if using *r*. If hypotheses given in words B0
		For $n = 30$, the 5% critical value is 0.3610	**B1**	**3.4**	For correct critical value
		Since $\lvert -0.2744 \rvert < 0.3610$ the result is not significant, so there is insufficient evidence to reject H_0	**M1**	**1.1**	For comparison and conclusion. FT their sensible pmcc and critical value provided both strictly between -1 and 1. Allow $-0.2744 > -0.3610$ but not $-0.2744 < +0.3610$

Question		Answer	Marks	AO	Guidance
		There is insufficient evidence at the 5% level to suggest that there is correlation between the cost of electricity and the amount of electricity being generated by wind	**A1** **[5]**	**2.2b**	For conclusion in words. Must be non-assertive and dep on correct values and hypotheses of correct form. Allow 'no evidence to suggest…' Do not allow 'sufficient evidence to suggest…' Do not ISW.

7	**(c)**	For very large samples, the critical value is very low.	**B1**	**2.4**	oe eg 'large sample size means lower values of *r* can be significant' eg large sample size means that the value given by the data is very close to the actual correlation coefficient in the population Accept any suitable answer – be generous.
		However in this case, although the correlation coefficient is significant, it is very close to zero so of very little real use.	**B1** **[2]**	**3.5a**	Oe
7	**(d)**	All of the correlation coefficients between generation and cost except 'gas' have small effect sizes.	**B1**	**2.2b**	Accept any suitable answers. All of the correlation coefficients between generation and cost have small or medium effect sizes
		The effect size of 0.42 between gas generation and cost suggests that the more gas is being used for generation, the more electricity costs.	**B1** **[2]**	**2.2b**	Must mention direction of correlation in context. Allow positive correlation Do not allow any credit for answers which do not involve the cost of electricity as question specifies cost of electricity Allow answers that mention positive correlation between gas generation and cost.

Question		Answer	Marks	AO	Guidance
8	(a)	Because the students would probably be tired after their run and so would run the second lap more slowly.	B1 [1]	2.2b	Allow other suitable answers Eg they will be warmed up so may run faster on the second lap
8	(b)	So that the data will be paired (so that she can simply compare the individual differences in the two lap times)	B1 [1]	2.4	Must mention 'pairing' or 'difference (in times)' or 'remove differences between individuals' Allow elimination of different fitness levels
8	(c)	**DR** Est. population mean $= \frac{72.2}{40} [= 1.805]$	B1	3.3	
		Est. population variance $= \frac{1}{39}\left(1510 - \frac{72.2^2}{40}\right) = \frac{1}{39} \times 1379.679$	M1	1.1	For attempt at variance. Finding sample variance (34.491…) scores M1A0
		= 35.376… NB pop sd = 5.9478….	A1	1.1	Allow if variance not stated but only SD
		Test is based on a Normal distribution or *t* distributn	B1	1.1	soi
		H_0: $\mu = 0$, H_1: $\mu > 0$,	B1	1.1a	Both correct; if stated in words only, must include 'population'. Can use a different letter if defined providing not $\bar{x}$
		where μ is the population mean difference between the two times (anticlockwise ─ clockwise)	B1	1.2	For definition of μ in context
		Test statistic is $\frac{1.805 - 0}{\sqrt{35.376/40}} = 1.919$	M1	3.4	For attempt at test statistic Alternative: calculate P($X > 1.805$) using N(0, 35.376/40) M1 = 0.02747 B1 and compare with 0.05 M1 conclusion A1
		Critical value (1-tailed) at 5% level is 1.645	B1	1.1	Allow $t_{39} = 1.685$ or $t_{50} = 1.676$ or $t_{30} = 1.697$
		1.919 > 1.645 so significant (reject H_0) or using *t*-value	M1	2.2b	Do not FT wrong critical value or test statistic

Question		Answer	Marks	AO	Guidance
		Sufficient evidence to suggest that the teacher is correct OR Sufficient evidence to suggest that students do run more quickly in a clockwise direction	**A1** **[10]**	**3.5a**	Must be non-assertive and dep on correct values and correct hypotheses Condone 'people' rather than 'students' if using the second version of the answer

Question		Answer	Marks	AO	Guidance
8	**(d)**	The weather conditions may have been different on the next day.	**B1** **[1]**	**2.3**	Allow other suitable answers. Do not allow 'tired' from previous day.

Question		Answer	Marks	AO	Guidance
9	(a)	$\lambda = \frac{0\times23+1\times42+\cdots+7\times2}{200}$	M1	3.3	For attempt at mean. Must use correct formula but allow one error.
		$= \frac{480}{200} = 2.4$	A1 [2]	1.1	M1A1 for $\lambda = 2.4$ seen
9	(b)	Cell C3 = 0.2177	B1	3.4	**BC**
		Cell D3 = 43.5446	B1FT	1.1	200 × their C3 (Accept 43.54 if use 0.2177)
		Cell E3 = $\frac{(42-43.5446)^2}{43.5446}$	M1FT	1.1	For correct calculation using their values
		= 0.0548	A1 [4]	1.1	BC (Accept 0.0545 if use 43.54)
9	(c)	Because otherwise some expected frequencies would be (less than 5 so) too small for the test to be valid.	B1 [1]	3.5b	For 'less than 5 or too small so invalid'
9	(d)	**DR** H_0: Poisson model is a good fit H_1: Poisson model is not a good fit	B1	2.5	H_0:Data is a good fit to Poisson gets B0
		$X^2 = 4.5931$	B1ft	1.1	FT Their value of E3. Allow if correct to 3sf.
		Refer to χ_5^2	B1	3.3	For degrees of freedom = 5 soi
		Critical value at 5% level = 11.07	B1	1.1	
		4.59 < 11.07 Result is not significant	M1	1.1	For comparison of their X^2 with 11.07. Allow $\chi_5^2(4.5931)=0.467$ or 0.468 < 0.95 so not significant for B1M1 and A1 if correct conclusion

		There is insufficient evidence to suggest that the Poisson (2.4) model is not a good fit.	**A1** **[6]**	**2.2b**	Conclusion in context of Poisson distribution, but do not need to mention 'trades per minute' or similar. Must be non-assertive and dep on correct values Do not allow 'Evidence to suggest Poisson is a good fit' Condone 'Data is a good fit to Poisson' if B0 above for hypotheses

Question		Answer	Marks	AO	Guidance
10	(a)	$P(X = 5) = 0.036864$ or $P(X = 6) = 0.004096$ Or $P(Y = 0) = 0.216$ or $P(Y = 1) = 0.432$ Or $P(Y_1 + Y_2 = 0) = 0.046556$ Or $P(Y_1 + Y_2 = 1) = 0.186624$	B1	1.1	**BC** Condone 0.037 or 0.0041 or better
		$P(T = 5) = 0.036864 \times 0.216^2 + 2 \times 0.004096 \times 0.216 \times 0.432$ Or $= 0.036864 \times 0.046656 + 0.004096 \times 0.186624$	M1 M1	3.1a 1.1	For either overall probability For both added with no extras
		= 0.002484	A1 [4]	1.1	Allow 0.0025 or better with working
10	(b)	Estimate of $P(T > 0) = 0.42$	B1 [1]	1.1	
10	(c)	**DR**			
		E(X) = 2.4 E(Y) = 1.2	B1	3.1a	Can be implied by $E(T) = 0$
		Var(X) = $6 \times 0.4 \times 0.6$ or Var(Y) = $3 \times 0.4 \times 0.6$	M1	1.2	For either
		Var(X) = 1.44 Var(Y) = 0.72	A1	1.1	For both M1A1 can be implied by $\text{Var}(t) = 2.88$
		(E(T) = 0) Var(T) = $1.44 + 2 \times 0.72$ $(= 2.88)$	M1	1.1	For their Var(X) + $2 \times$ their Var(Y)
		[E(mean) = 0] Var(mean) = $\frac{2.88}{100}$ $[= 0.0288]$	M1	1.1	For their variance divided by 100
		(By CLT) distribution is approx $N(0, 0.0288)$	B1	2.2a	
		For use of continuity correction $0.255 = \frac{51}{200}$	B1	3.4	
		P(mean > 0.255) = 0.06647	A1 [8]	1.1	**BC** Without cc P(mean > 0.25) = 0.0704 gets M1B0A1 Allow 0.066 with working.

Question			Answer	Marks	AO	Guidance
11	(a)		$F(1) = \frac{a+b}{24} - \frac{4}{3} = 0.5$ or $\frac{a+b}{24} = \frac{11}{6}$ or $F(2.5) = \frac{2.5a+b}{37.5} - \frac{4}{3} = 0.8$ or $\frac{2.5a+b}{37.5} = \frac{32}{15}$	B1	3.1a	Allow any correct form for either
			$a + b = 44 \quad 2.5a + b = 80$	M1	1.1	Attempt to solve their two equations to get as far eliminating one variable
			$a = 24\ b = 20$	A1 [3]	2.1	**AG** must see some working leading to solution
11	(b)	(i)	$F(0) = \frac{24\times0+20}{9\times0+15} - \frac{4}{3} = 0$ Allow $F(0) = \frac{20}{15} - \frac{4}{3} = 0$	B1 [1]	2.1	
11	(b)	(ii)	$F(x) = \frac{24x+20}{9x+15} - \frac{4}{3} \Rightarrow F'(x) = \frac{24(9x+15)-9(24x+20)}{(9x+15)^2}$	M1	2.1	For differentiation Must use quotient rule correctly but allow one error as long as not in sign of udv
			$F'(x) = f(x) = \frac{180}{(9x+15)^2}$	A1	1.1	Must cancel the x-terms for A1 but can have $360 - 180$ as the numerator
			So $F'(x) > 0$ [so increasing] so non-decreasing	A1	2.2a	Must state non-decreasing
			Alternative Method $F(x) = \frac{72x+60}{3(9x+15)} - \frac{4(9x+15)}{3(9x+15)}$	M1		For expressing with common denominator
			$F(x) = \frac{12x+20-20}{9x+15} = \frac{4}{3} - \frac{20}{9x+15}$	A1		
			As x increases $\frac{20}{9x+15}$ decreases and so $F(x)$ increases	A1		
				[3]		

Question			Answer	Marks	AO	Guidance
11	(c)	(i)	Property is $F(5) = 1$.	B1 [1]	3.1a	Allow F(Upper bound) = 1 Allow $F(5) - F(0) = 1$ Do not allow '$F(x) \geqslant 0$ for all x' or $0 \leqslant F(x) \leqslant 1$ for all x since this is implied by previous properties Do not allow area under $F(x)$ is 1 Must be a property that cannot be found from properties already given.
11	(c)	(ii)	$F(5) = \frac{24\times5+20}{9\times5+15} - \frac{4}{3} = \frac{140}{60} - \frac{4}{3} = 1$	B1 [1]	2.1	We need to see either $\frac{24\times5+20}{9\times5+15} - \frac{4}{3}$ or $\frac{140}{60} - \frac{4}{3}$ oe
11	(d)		$\frac{24x+20}{9x+15} - \frac{4}{3} = \frac{3}{4}$ $24x + 20 = \frac{25}{12}(9x + 15)$ $x = \frac{15}{7}$	B1 M1 A1 [3]	3.1a 2.1 1.1	For attempt to solve Allow one slip in multiplication. Must use 0.75
11	(e)		$E(X) = \int_0^5 \frac{180x}{(9x+15)^2} dx$ = 1.414	B1 B1 [2]	1.1 1.1	FT their f(x) if of form $\frac{k}{(9x+15)^2}$. For first B1 only Limits can be implied by correct answer. **BC** Allow 1.4 with correct integral seen
11	(f)		$f'(x) = \frac{-2\times9\times180}{(9x+15)^3} \left[= \frac{-3240}{(9x+15)^3}\right]$ $f'(x)$ is always negative (for $x \geq 0$)so decreasing (as x increases), so mode = 0	B1 DB1 [2]	1.1 3.1a	

Question		Answer	Marks	AO	Guidance
12		$\mathrm{E}(X_i) = 0.1,\ \mathrm{Var}(X_i) = 0.09$ or $0.1 - 0.1^2$	B1	1.1	Explicitly seen (both stated, and not embedded eg not in a statement such as $\mathrm{E}(Y) = 64 \times \mathrm{E}(X) = 64 \times 0.1$)
		$Y = X_1 + X_2 + \cdots + X_{64}$	B1	3.1a	No further marks if sums not seen anywhere
		$\mathrm{E}(Y) = \mathrm{E}(X_1) + \mathrm{E}(X_2) + \cdots + \mathrm{E}(X_{64})$	M1	2.1	For sum of means
		$= 64 \times \mathrm{E}(X_i) = 64 \times 0.1 = 6.4$	A1	1.1	**AG** SCB1 for E(Y) = 64×E(X) = 6.4, Not simply *np*
		$\mathrm{Var}(Y) = \mathrm{Var}(X_1) + \mathrm{Var}(X_2) + \cdots + \mathrm{Var}(X_{64})$	M1	2.1	For sum of variances
		$= 64 \times \mathrm{Var}(X_i) = 64 \times 0.09 = 5.76$ so $\sigma = 2.4$	A1	1.1	**AG** SCB1 for Var(Y) = 64×Var(X) = 5.76 so $\sigma = 2.4$. Not simply *npq*.
			[6]		

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