OCR
Oxford Cambridge and RSA

GCE

Further Mathematics B MEI

Y422/01: Statistics major

A Level

Mark Scheme for June 2023

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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.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 or the RM Assessor messaging system, or by email.

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 a tick to confirm that the work has been seen.

7. Award No Response (NR) if:
    - there is nothing written in the answer space

Award Zero '0' if:

- anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

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:
    a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
    b. **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
E	Explanation mark 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining a result or establishing a given result
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.
BP	Blank Page
Seen	
Highlighting	

12. **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.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

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. E marks are lost unless, by chance, the given results are established by equivalent working. 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(4 sixes) = $\left(\frac{1}{6}\right)^4 = \frac{1}{1296}$	B1 [1]	1.1	AG
1	(b)		Random or independent Fixed probability of success Fixed number of trials	B1	2.4	For two correct statements
			The random variable is the number of successes oe There are only 2 outcomes	B1	2.4	For at least 4 correct comments
			Because n (= 10000) is large and p (= $\frac{1}{1296}$) is small a Poisson distribution is also appropriate	B1 [3]	2.4	For explanation of Poisson. Must mention Poisson. .
1	(c)		Poisson$\left(\frac{10000}{1296}\right)$ or Poisson(7.716…) or Poisson$\left(\frac{625}{81}\right)$	M1	3.3	
			P(X = 10) = 0.0919	A1	1.1	**BC** 0.091864…
			P(X > 10) = 0.157	A1 [3]	1.1	**BC** 0.156963…
1	(d)		P(A person does not throw 4 sixes in 20 tries) = $\left(\frac{1295}{1296}\right)^{20} = [0.98468\ldots]$	M1	3.1b	
			B(50, 1 – 0.98468…) [=B(50, 0.015319…)]	M1	3.3	Or Poisson approx. mean 0.765975 (from 50×0.015319)
			P(No more than 2) = 0.9586	A1 [3]	1.1	**BC** 0.958647… Poisson approx. leads to 0.9573… Allow awrt 0.96 NB Using B(50, 20/1296 or 5/324) gets answer 0.9579 but scores zero

NB: Throughout the paper allow probabilities given to 2sf if the distribution being used is stated.

Question			Answer	Marks	AO	Guidance
2	(a)		Prediction for 5 °C is 960 or 962 Prediction for −4 °C is 1050 or 1054	B1 B1 [2]	1.1 1.1	Only allow 1 mark max if either given to more than 4sf
2	(b)		Although prediction for 5 °C lies within the data (interpolation), the points do not lie too close to the line, so it is not too reliable. and the value of r^2 is not too close to 1 so the estimate is only moderately reliable. The prediction for −4 °C is even less reliable since it is an extrapolation.	B1 B1 B1 [3]	2.2a 3.5b 3.5b	Allow first B1 for any correct comment about 5°C Condone 'Near the centre of the data' Allow second B1 for all 3 correct comments about 5°C

Question			Answer	Marks	AO	Guidance
3	(a)		P(none in 3 serves) = $0.45^3 = 0.0911$	B1 [1]	1.1	(0.091125…)
3	(b)		B(20, 0.55) P(Ten or more) = 1 – 0.2493 = 0.7507	M1 A1 [2]	3.3 1.1	s.o.i. **BC**
3	(c)		P(fifth serve) = $0.45^4 \times 0.55$ = 0.0226	M1 A1 [2]	3.3 1.1	(0.022553…)
3	(d)		4 successes in first nine so B(9, 0.55) then × 0.55 P(fifth on tenth serve) = 0.2128 × 0.55 = 0.117	M1 A1 [2]	3.1b 1.1	**BC** (0.117016…)
3	(e)		$p(1-p) = 0.2496$ $p^2 - p + 0.2496 = 0$ $p = 0.48$ or $p = 0.52$, so answer $p = 0.48$	M1 M1 A1 [3]	3.1a 1.1 2.2a	For expressing in the form $ax^2 + bx + c = 0$

Question			Answer	Marks	AO	Guidance
4	(a)		10 sheets thickness ~ N(10×3.125, 10×0.03^2)	**M1**	**3.3**	For Normal and mean
			i.e. N(31.25, 0.009)	**A1**	**1.1**	For correct variance
			P(thickness < 31) = 0.0042	**B1**	**3.4**	**BC** (Exact answer 0.00420…)
				[3]		
4	(b)		Thickness ~ N(10×3.125, $10^2 \times 0.03^2$)	**B1**	**3.3**	For correct distribution
			i.e. N(31.25, 0.09)			
			P(thickness < 31) = 0.2023	**B1**	**1.1**	**BC** (Exact answer 0.202328……)
			Alternative method			
			P(10 sheets < 31) = P(1 sheet <3.1)	**B1**		
			P(thickness < 31) = 0.2023	**B1**		**BC**
				[2]		
4	(c)		One of each ~ N($3.125+3.117+3.109$, 3×0.03^2)	**M1**	**3.3**	For method
			i.e. N(9.351, 0.0027)	**A1**	**1.1**	
			P(Total ≥ 9.4) = 0.1728	**B1**	**1.1**	**BC** (Exact answer 0.172839…)
				[3]		
4	(d)		Distribution of difference of 10 sheets of each has			oe
			mean = $10 \times 3.125 - 10 \times 3.117$	**M1**	**3.3**	Method for mean
			variance = $10 \times 0.03^2 + 10 \times 0.03^2$	**M1**	**1.1**	Method for variance
			[so distribution is N(±0.08, 0.018)]			
			P(difference < 0) = 0.2755	**A1**	**3.4**	**BC** Allow 0.275 or 0.276 (exact answer 0.27549…)
				[3]		

Question			Answer	Marks	AO	Guidance
5	(a)		Est of pop variance = $\frac{15065-\frac{765^2}{40}}{39}$	M1	1.1	Accept denominator of 40 rather than 39 for M1 leading to est of var = 10.859 or sd =3.295
			$= 11.138 \quad = \left[\frac{3475}{312}\right]$	A1	1.1	Allow 11.1 or sd = 3.34 (3.33736…)
			Confidence interval is 19.125	B1	1.1	Or $\frac{765}{40}$ seen anywhere
			± 1.96	M1	3.3	Accept *t*-value of 2.02 to 2.03
			$\times \sqrt{\frac{11.138}{40}}$	M1	1.1	For $\sqrt{\frac{their\ variance}{40}}$
			= 19.125 ± 1.034 or (18.09, 20.16)	A1 [6]	3.4	Accept based on *t*-distribution from correct working *t* = 2.02 leads to (18.06, 20.19) *t* = 2.0227 leads to (18.044, 20.206) *t* = 2.03 leads to (18.0422, 20.1961)
5	(b)		It does to some extent because the confidence interval does contain 20	E1	3.5a	Must be unassertive FT their interval
			But there is a lot of variation so estimates are not very accurate.	E1 [2]	2.2b	Allow other suitable comments. Allow valid comment on variation relating to the claim EG Might not be representative of the population. Lower confidence level could result in 20 being outside. Near the end of interval so not very reliable. The interval is wide.
5	(c)		If the population from which the sample was drawn was Normally distributed then you could have formed it using the *t* distribution.	E1	2.2a	Allow 'don't know if population is Normally distributed so cannot use the *t* distribution.
			If not then you could not have formed it, due to the small sample size	E1 [2]	2.4	Max 1 mark if *t* distribution not mentioned. Marks are independent so can get mark for second comment only
5	(d)		19.25 < μ < 20.11	B1 [1]	1.1	
5	(e)		It suggests that he may be correct because the interval again contains 20	E1	2.2b	Must be unassertive. Do not allow 'Amari is correct'
			And the variance is much lower this time	E1 [2]	3.5a	Allow 'The centre of the interval is nearer to 20 this time' Allow 'This interval is narrower.

Question			Answer	Marks	AO	Guidance
6	(a)		Scatter diagram appears to be roughly elliptical so the distribution may be bivariate Normal	E1 E1 [2]	3.5a 2.4	Condone 'The data is bivariate normal' or 'The data comes from a bivariate normal distribution'??
6	(b)		**DR** $S_{xy} = 4713.62 - \frac{1}{20} \times 342.10 \times 273.65$ [= 32.837] $S_{xx} = 5989.53 - \frac{1}{20} \times 342.10^2$ [= 137.91] $S_{yy} = 3919.53 - \frac{1}{20} \times 273.65^2$ [= 175.31] $r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = \frac{32.837}{\sqrt{137.91 \times 175.31}}$ = 0.211	M1 M1 M1 A1 [4]	1.1a 1.1 3.3 1.1	For S_{xy} For either S_{xx} or S_{yy} For general form including sq. root Allow awrt 0.21 without incorrect working
6	(c)		H_0: $\rho = 0$, H_1: $\rho \neq 0$ where ρ is the population pmcc between x and y For n = 20, the 5% critical value is 0.4438 Since 0.211 < 0.4438 the result is not significant, so there is insufficient evidence to reject H_0 There is insufficient evidence at the 5% level to suggest that there is correlation between download and upload speed [5]	B1 B1 B1 M1 A1	3.3 2.5 3.4 1.1 2.2b	For both hypotheses Allow any symbol in place of ρ if defined as population pmcc For defining ρ NB Hypotheses in words only get B1 unless population mentioned 'between x and y' may be seen in the hypotheses alongside the correct hypotheses in symbols, rather than in the definition of ρ For correct critical value For comparison and conclusion Must be in context FT their pmcc and cv (provided between -1 and +1) for M1 but not for A1

Question			Answer	Marks	AO	Guidance
6	(d)		Because download speed would not have a probability distribution (so the distributional assumption could not be met).	E[1]	2.2a	Allow 'the situation is not sampling from a bivariate Normal population' or 'Statistical inference cannot be carried out for non-random data'. Allow other suitable answers.
				[1]		E0 for 'pmcc can only be found for random variables'

Question			Answer	Marks	AO	Guidance
7	(a)		The Normal probability plot is roughly straight and the *p*-value is not too low	E1	1.1	No marks if Wilcoxon suggested
			which are both consistent with the data coming from a Normal distribution	E1	2.2b	
			A *t* test should be carried out (since this test requires the population to be Normally distributed)	B1	3.3	Dependent on at least 1 of the previous marks
				[3]		
7	(b)		**DR**			No marks for Wilcoxon except for mean and sd if found
			H_0: $\mu = 1.0$ H_1: $\mu > 1.0$	B1	1.1a	Hypotheses in words only must include "population". Allow H_0: $\mu = 0.01$ H_1: $\mu > 0.01$
			Where μ is the population mean concentration	B1	1.2	For definition in context. Must include population.
			Sample mean = 1.015	B1	1.1	
			Sample SD = 0.0981	B1	1.1	
			Test statistic is $\frac{1.015-1.0}{0.0981/\sqrt{12}}$	M1	3.3	FT their mean and/or sd
			= 0.530	A1	1.1	
			Use of t_{11}	M1	3.4	No FT if not t_{11} Can be implied by 1.796 or 2.201 OR *p*-value = 0.3034 and compare with 5%
			Critical value (1-tailed) at 5% level is 1.796	A1	1.1	
			0.530 < 1.796 not significant (do not reject H_0)	M1	2.2b	Or confidence interval method [0.9641, 1.0659]
			Insufficient evidence to suggest that the mean concentration exceeds 1.0%	E1	3.5a	Answer must be in context FT their sensibly obtained test statistic and cv (provided from t_{11}) for M1 but not for A1
				[10]		

Question			Answer	Marks	AO	Guidance
8	(a)		$2 \times \frac{3}{10} \times \frac{7}{10}$ $= \frac{42}{100}$ or $\frac{21}{50}$ or 0.42	M1 A1 [2]	1.1 1.1	For $\frac{3}{10} \times \frac{7}{10}$ or 0.3×0.7
8	(b)		$P(T \leq 25) = 0.5$	B1 [1]	1.1	
8	(c)		$P(T \leq 25) = \frac{48}{100}$ or $\frac{12}{25}$ or 0.48 $P(T > 35) = \frac{7}{100}$ or 0.07	B1 B1 [2]	1.1 1.1	
8	(d)		**DR** $E(X) = 5$ $Var(X) = \frac{1}{12}(10-0)^2$ $= \frac{25}{3}$ $E(T) = 25$ $Var(T) = \frac{125}{3}$ $[E(Y) = 25]$ $Var(Y) = \frac{125}{300}$ $\left[= \frac{5}{12}\right]$ By CLT distribution is approx $N\left(25, \frac{5}{12}\right)$ $P(Y > 26) = 0.0607$	B1 M1 A1 M1 M1 M1 A1 [7]	3.1a 1.2 1.1 1.1 1.1 2.2a 1.1	s.o.i. Allow M0A0 SCB1 if $\frac{25}{3}$ used below but not explicitly found without full explanation. Allow $Var(T) = 5\times$ their $Var(X)$ Allow $Var(Y)$ = their $Var(T)/100$ **BC** (0.060667…) Do not allow a continuity correction Allow equivalent method M1 for $Var(T) = \frac{125}{3}$, M1 for $Var(\text{total of 100 values}) = \frac{12500}{3}$, M1 for $N(2500, \frac{12500}{3})$, A1 for $P(\text{Total} > 2600) = 0.0607$

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO</th><th>Guidance</th></tr>
<tr><td>9</td><td>(a)</td><td></td><td>DR
H_0: no association between where registered and passing distance
H_1: some association between where registered and passing distance
<table><tr><td>Expected</td><td>Local</td><td>Non-local</td></tr><tr><td>Under 1.5m</td><td>15.55</td><td>7.45</td></tr><tr><td>At least 1.5m</td><td>153.45</td><td>73.55</td></tr></table><table><tr><td>Contribution</td><td>Local</td><td>Non-local</td></tr><tr><td>Under 1.5m</td><td>0.8096</td><td>1.6893</td></tr><tr><td>At least 1.5m</td><td>0.0820</td><td>0.1712</td></tr></table>$X^2 = 2.75$

Use of χ^2_1

Critical value at 5% level = 3.84;
2.75 < 3.84 so not significant (do not reject H_0)

There is insufficient evidence to suggest that there is an association between where registered and passing distance.

[9]</td><td>B1

M1

A1

B1

B1

B1
M1

E1</td><td>3.3

3.4

1.1

1.1

1.1

2.5
2.2b
2.2b

3.5a</td><td>Allow hypotheses and conclusion in terms of independence, but not relationship or correlation which results in B0 and final E0 Context needed in at least one of the hypotheses

For at least 1 correct expectation

For all correct

At least one correct value must be seen; this mark cannot be implied merely by a correct final value of X^2. Allow 1 error.

Allow 2.76 from expected values given to 2dp
Yates' correction is not expected, but full marks if used correctly
<table><tr><td>Contribution</td><td>Local</td><td>Non-local</td></tr><tr><td>Under 1.5m</td><td>0.5975</td><td>1.2467</td></tr><tr><td>At least 1.5m</td><td>0.0605</td><td>0.1263</td></tr></table>$X^2 = 2.03$

Can be implied by correct critical value of 3.84 or by 2.706 or 5.024. Must be from chi-squared with 1 deg of freedom
OR p-value = 0.09725 and compare with 5%
FT their sensibly obtained test statistic and cv for M1 but not for A1

If hypotheses wrong way around do not allow first or last two marks. Must mention 'insufficient evidence' in conclusion, not just 'insufficient evidence to reject H_0' followed by a completely new sentence.</td></tr>
<tr><td>9</td><td>(b)</td><td></td><td>Because the cyclist will know whether or not the car is locally registered when she notes the passing distance

[1]</td><td>E1</td><td>2.2b</td><td>Allow other reasonable answers
Do not allow 'She may not be able to estimate accurately'</td></tr>
</table>

Question			Answer	Marks	AO	Guidance
10	(a)		$\mathrm{F}(x) = \int_1^x \frac{4}{15}\left(\frac{a}{u^2} + 3u^2 - \frac{7}{2}\right)\mathrm{d}u$	M1	2.1	For attempt to integrate (Condone ito x). No need for limits.
			$= \frac{4}{15}\left[-\frac{a}{u} + u^3 - \frac{7}{2}u\right]_1^x$	M1	1.1a	For correct integral (Condone ito x) No need for limits.
			$= \frac{4}{15}\left(-\frac{a}{x} + x^3 - \frac{7}{2}x\right) - \frac{4}{15}\left(-a - \frac{5}{2}\right)$	A1	1.1	A1 for correct answer AEF
			$\mathrm{F}(x) = 0$ for $x < 1$ $\mathrm{F}(x) = \frac{4}{15}\left(-\frac{a}{x} + x^3 - \frac{7}{2}x + a + \frac{5}{2}\right)$ for $1 \le x \le 2$ $\mathrm{F}(x) = 1$ for $x > 2$	A1 [4]	1.1	Fully correct AEF $\left[= \frac{4}{15}\left(a\left(1 - \frac{1}{x}\right) + x^3 - \frac{7}{2}x + \frac{5}{2}\right)\right]$ Or using F(2) = 1 leads to $\frac{4}{15}\left(-\frac{a}{x} + x^3 - \frac{7}{2}x + \frac{11}{4} + \frac{1}{2}a\right)$
10	(b)		$\mathrm{F}(2) = 1 \Rightarrow \frac{4}{15}\left(-\frac{a}{2} + 8 - 7\right) - \frac{4}{15}\left(-a - \frac{5}{2}\right) = 1$ $\Rightarrow \frac{2}{15}a + \frac{14}{15} = 1$	M1	3.1a	For setting their F(2) = 1.. Their F(x) must be i.t.o. a $\left[\Rightarrow \mathrm{F}(x) = \frac{4}{15}\left(-\frac{0.5}{x} + x^3 - \frac{7}{2}x + 3\right) = 1\right]$
			$a = 0.5$	A1 [2]	1.1	NB Alternative method $\mathrm{F}(2) - \mathrm{F}(1) = 1$ leads to same equation if correct but FT their $\mathrm{F}(x)$ for M1. Condone a wrong constant term in $\mathrm{F}(x)$ which leads to a correct value of a
10	(c)		$\frac{4}{15}\left(-\frac{a}{m} + m^3 - \frac{7}{2}m\right) + 0.8 = 0.5$ Or $\frac{4}{15}\left(-\frac{a}{m} + m^3 - \frac{7}{2}m + 3\right) = 0.5$ $8\left(-\frac{0.5}{m} + m^3 - \frac{7}{2}m\right) = -9$ $\Rightarrow 8m^4 - 28m^2 + 9m - 4 = 0$	M1 A1 [2]	2.1 1.1	For setting their F(m) = 0.5 Condone F(x) = 0.5 Or $\int_1^m \frac{4}{15}\left(\frac{a}{u^2} + 3u^2 - \frac{7}{2}\right) = 0.5$ followed by attempt at integration **AG** Must show at least one line of correct working

Question			Answer	Marks	AO	Guidance
10	(d)		F(1.735) = 0.4965, F(1.745) = 0.5119	B1	3.4	For either OR evaluation of $8m^4 - 28m^2 + 9m - 4$ for 1.735 (= −0.1797) and 1.745 (= 0.6217), so change of sign
			So median is 1.74 to 2 dp	E1 [2]	1.1	No marks for calculator answer
10	(e)		$\mathrm{E}(X) = \int_1^2 \frac{4}{15}x\left(\frac{0.5}{x^2} + 3x^2 - \frac{7}{2}\right)\mathrm{d}x$	M1	1.1	Allow with wrong value of *a* or ito *a*. Correct limits required.
			= 1.69	A1 [2]	1.1	**BC** (1.692419…) or $\frac{2}{15}\ln 2 + \frac{8}{5}$
10	(f)		$\mathrm{f}'(x) = \frac{4}{15}\left(-\frac{1}{x^3} + 6x\right)$	M1	3.1a	Allow with wrong value of *a*
			$\mathrm{f}''(x) = \frac{4}{15}\left(\frac{3}{x^4} + 6\right)$	M1	1.1	Allow with wrong value of *a* Alternatives for second mark: When $x = \sqrt[4]{\frac{1}{6}}$ the curve has a minimum; For $1 \le x \le 2$, $6x$ is clearly greater than $\frac{1}{x^3}$ so f' is positive
			hence f is increasing so mode = 2	A1 [3]	1.1	Allow third mark if full answer based on the above. Allow SCB1 for mode = 2 without proper justification

Question			Answer	Marks	AO	Guidance
11	(a)		$E(X) = p$ $E(X^2) = p$ $Var(X) = p - p^2$	**B1** **M1** **A1** **[3]**	**1.1** **1.1** **1.1**	
11	(b)		$Y = X_1 + X_2 + \cdots + X_{50}$ where $p = 0.2$, giving $E(X_i) = 0.2$, $Var(X_i) = 0.2 \times (1 - 0.2) = 0.16$ $E(Y) = E(X_1) + E(X_2) + \cdots + E(X_{50})$ $= 50 \times E(X_i) = 50 \times 0.2 = 10$ $Var(Y) = Var(X_1) + Var(X_2) + \cdots + Var(X_{50})$ $= 50 \times Var(X_i) = 50 \times 0.16 = 8$	**B1** **B1** **M1** **A1** **M1** **A1** **[6]**	**3.1a** **1.1** **2.1** **1.1** **2.1** **1.1**	 Seen **AG** SCB1 for use of results of part a and $E(Y) = 50 \times E(X)$, (Where the Xi are all independent) . Not simply *np*. **AG** SCB1 for use of results of part a and $Var(Y) = 50 \times Var(X)$. Not simply *npq*.

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