



GCE

Further Mathematics B (MEI)

Y412/01: Statistics A

Advanced Subsidiary GCE

Mark Scheme for June 2019

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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.

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Annotations and abbreviations

Annotation in scoris	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
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 *
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 indicates that the instruction In this question you must show detailed reasoning appears in the question.

Subject-specific Marking Instructions for AS Level Further Mathematics B (MEI)

- a Annotations should be used whenever appropriate during your marking. The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded. For subsequent marking you must make it clear how you have arrived at the mark you have awarded.
- 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 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

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. This rule should be applied to each case. When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. Accept any value within a probability model, that agrees with the correct value to 4d.p.. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination. There is no penalty for using a wrong value for g . E marks will be lost except when results agree to the accuracy required in the question.
- g Rules for replaced work: if a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests; if there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others. NB Follow these maths-specific instructions rather than those in the assessor handbook.
- 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 mark in the question. Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working. ‘Fresh starts’ will not affect an earlier decision about a misread. 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, of course, that there is nothing in the wording of the question specifying that analytical methods are required). 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	AOs	Guidance												
1	(a)	<table border="1"> <tr> <td>r</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> </tr> <tr> <td>$P(X=r)$</td> <td>$4k$</td> <td>$10k$</td> <td>$18k$</td> <td>$28k$</td> <td>$40k$</td> </tr> </table>	r	1	2	3	4	5	$P(X=r)$	$4k$	$10k$	$18k$	$28k$	$40k$	B1 [1]	1.1	
	r	1	2	3	4	5											
	$P(X=r)$	$4k$	$10k$	$18k$	$28k$	$40k$											
	(b)	$4k + 10k + 18k + 28k + 40k = 1$ $100k = 1$ (so $k = 0.01$)	B1 B1 [2]	2.4 1.1	For equation For $100k = 1$ leading to given answer AG												
	(c)		B1 B1 [2]	1.1 1.1	For graph with axes correctly labelled For line graph with correct heights B0 if tops of lines/points joined.												
(d)	The distribution has negative skew	B1 [1]	1.1														
(e)	$E(X) = 3.9$ $\text{Var}(X) = 1.33$	B1 B1 [2]	1.1a 1.1	BC BC													

Question		Answer	Marks	AOs	Guidance
2	(a)	Binomial. $n = 2000, p = 1/1500$ Poisson $\lambda = 4/3$	M1 A1 M1 A1 [4]	3.3 1.1 3.3 1.1	For Binomial. Allow B(...) For parameters correct to at least 3 s.f. For Poisson. Allow Po(...). Do not allow P(...) For parameter correct to at least 3 s.f.
	(b)	$P(X = 2) = 0.2343$ (Poisson) or 0.2344 (Binomial) $P(X > 2) = 1 - 0.8494$ $= 0.1506$	B1 M1 A1 [3]	1.1 1.1 1.1	BC Allow answers from binomial or Poisson distributions Allow 0.234www BC Allow 0.151www
	(c)	Use of $B\left(20\,000, \frac{1}{1500}\right)$ Or $P(\geq 10) = 1 - 0.1448$ $= 0.8552$ allow 0.855www	M1 A1 [2]	1.1 1.1	Or use of $Po\left(\frac{40}{3}\right)$ $P(\geq 10) = 1 - 0.1449$ $= 0.8551$ allow 0.855www

3	(a)	Uniform on the values $\{10, 20, \dots, 80\}$	B1 B1 [2]	3.3 1.2	For uniform For values of uniform distribution stated SC1 For case when 'uniform' not stated but correct uniform distribution is tabulated.
	(b)	$P(X \geq 40) = \frac{5}{8}$	B1 [1]	1.1	
	(c) (i)	Variance for 1 roll $= 10^2 \times \frac{8^2 - 1}{12}$ $= 525$ So variance for 3 rolls $= 1575$	M1 A1 B1 [3]	3.3 1.1 1.1	Or M1 for applying $E[X^2] - E^2[X]$ to correct distribution FT for 3×their variance for 1 roll
	(c) (ii)	$P(X < 30) = \frac{1}{4}, P(30 \leq X \leq 50) = P(X > 50) = \frac{3}{8}$ Required probability $= 6 \times \frac{1}{4} \times \frac{3}{8} \times \frac{3}{8}$ $= \frac{27}{128}$ or 0.2109	B1 M1 A1 [3]	3.1a 1.1 1.1	For any one of these For 6×product of their three probabilities Allow 0.211www or 0.21www

Question		Answer	Marks	AOs	Guidance
4	(a)	$H_0: \rho = 0$ $H_1: \rho \neq 0$ Where ρ is the (population) correlation coefficient between openness and conscientiousness Critical value at 10% level is 0.5494 $0.476 < 0.5494$ so not significant Insufficient evidence to suggest that there is correlation between openness and conscientiousness	B1 B1 B1 M1 A1 [5]	3.3 2.5 3.4 2.2b 1.1	Allow other symbols only if defined as population correlation coefficient For definition of ρ in context. Condone use of 0.549 No further marks if incorrect c.v. used. M1 for sensible comparison leading to a conclusion For non-assertive correct conclusion in terms of H_1 . See additional notes.
	(b)	For the second test the sample size was 'much larger'. This would lead to a smaller critical value , even at 5% level, which could explain the significant result with a lower test statistic.	B1 [1]	2.2b	Accept reasonable alternatives.
	(c)	Possible answers: No correlations have large effect size. Only 5 out of 10 correlations are significant at the 5% level	B1 B1 [2]	2.2b 2.2b	For a suitable summary comment relating to effect size . e.g. All correlations involving Agreeableness have small effect size. For a further suitable summary comment relating to either effect size or significance. e.g. Three out of the four correlations involving Neuroticism are found to be significant.

Question		Answer	Marks	AOs	Guidance
5	(a)	<p>Mean number of females per litter =</p> $\frac{20 \times 0 + 45 \times 1 + \dots + 2 \times 7}{200} = \frac{490}{200} = 2.45$ <p>$np = 2.45$ with $n = 7$ ($p = 0.35$)</p>	<p>B1</p> <p>B1</p> <p>[2]</p>	<p>1.1</p> <p>1.1</p>	<p>For $7p = 2.45$ leading to given answer AG SC There are 490 females out of 1400 offspring so $p = 490/1400 = 0.35$ gets SC2 $p = 490/1400$ with no further explanation gets SC1</p>
	(b)	<p>prob = $0.18477\dots \times 200$ or $0.29848\dots \times 200$ For 1, exp freq = 36.9553 4d.p. For 2, exp freq = 59.6970 4 d.p. For 3 Contribution = $\frac{(37 - 53.5742)^2}{53.5742}$ = 5.1275</p>	<p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>[4]</p>	<p>3.4</p> <p>2.2a</p> <p>1.1a</p> <p>1.1</p>	<p>For method for either</p> <p>Allow second value to be found by subtraction. Allow 36.96 and 59.70</p> <p>Allow 5.13</p>
	(c)	<p>H_0: binomial model is suitable H_1: binomial model is not suitable $X^2 = 30.98$ Refer to χ_4^2 Critical value at 5% level = 9.488 $30.98 > 9.488$ Significant result There is sufficient evidence to suggest that the binomial model is not suitable</p>	<p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>[6]</p>	<p>3.3</p> <p>1.1</p> <p>3.4</p> <p>1.1</p> <p>1.1</p> <p>2.2b</p>	<p>Allow 'the binomial model fits/does not fit the data'</p> <p>For 4 degrees of freedom. No further marks form here if wrong. For comparison leading to a conclusion. FT their test statistic For non-assertive correct conclusion in terms of H_1.</p>
	(d)	<p>e.g. More litters than expected have very few (0 or 1) females. The observed data shows a more positive skew than the binomial model. The diagram shows that the observed data has more variation than the binomial distribution would suggest.</p>	<p>B1</p> <p>[1]</p>	<p>2.2b</p>	<p>For any one of these comments Accept suitable alternatives which highlight specific differences between probabilities and relative frequencies.</p>

Question		Answer	Marks	AOs	Guidance
6	(a)	Because the test is only valid for random on random and the altitudes are not random variables but controlled	B1 B1 [2]	3.5a 3.5b	
	(b)	Because altitude is the independent variable	B1 [1]	2.4	Allow 'controlled', 'selected' for 'independent'
	(c)	$b = \frac{S_{xy}}{S_{xx}} = \frac{176090 - (21200 \times 105.4 / 12)}{39100000 - 21200^2 / 12}$ $= -0.00614 \text{ 3 s.f.}$ $\bar{x} = 1766.666\dots, \bar{y} = 8.783333\dots$ hence least squares regression line is: $y - 8.7833\dots = -0.00614(x - 1766.666\dots)$ $y = -0.00614x + 19.637$	M1 A1 M1 A1 [4]	1.1a 1.1 1.1 1.1	For correct structure to find gradient (<i>b</i>) as written or equivalent e.g. $\frac{176090/12 - (1766.7 \times 8.783)}{39100000/12 - 1766.7^2}$ For <i>b</i> correct to 3 s.f. or better For equation of line with their $b < 0$ Values correct to 3 s.f. or better
	(d)	Prediction for 2000m is 7.35 °C Prediction for 3000m is 1.21 °C	B1 B1 [2]	3.4 1.1	Allow 7.36 Allow 1.22 FT their equation with $b < 0$
	(e)	Prediction for 2000m is more likely to be reliable as interpolation Prediction for 3000m is less likely to be reliable as extrapolation	B1 B1 [2]	3.5a 3.5b	If 'interpolation' not stated then alternative wording must be convincing - e.g. 'within domain of validity' If 'extrapolation' not stated then alternative wording must be convincing. e.g. allow 'outside the range of the data (values)'
	(f)	Residual = $8.1 - (-0.00614 \times 1600 + 19.637)$ $= -1.71 \quad 3 \text{ s.f.}$	M1 A1 [2]	1.1 1.1	For difference between 8.1 and their prediction for 1600 For - 1.71 FT their $b < 0$

Additional notes RE:Non-assertive conclusions relating to H_1 in hypothesis tests

There is insufficient evidence to **believe/suggest/indicate** that there is an association between...

There is insufficient evidence to **believe/suggest/indicate** that... ..are not independent.

There is sufficient evidence to **believe/suggest/indicate** that there is an association between...

There is sufficient evidence to **believe/suggest/indicate** that... ..are not independent.

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