Level 3 Certificate

Certificate Quantitative Problem Solving (MEI)

H869/02: Statistical Problem solving

OCR Level 3 Certificate

Mark Scheme for November 2020

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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.

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
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method 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

1. **Subject-specific Marking Instructions**

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, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) 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, eg 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, eg 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, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

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 Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

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.

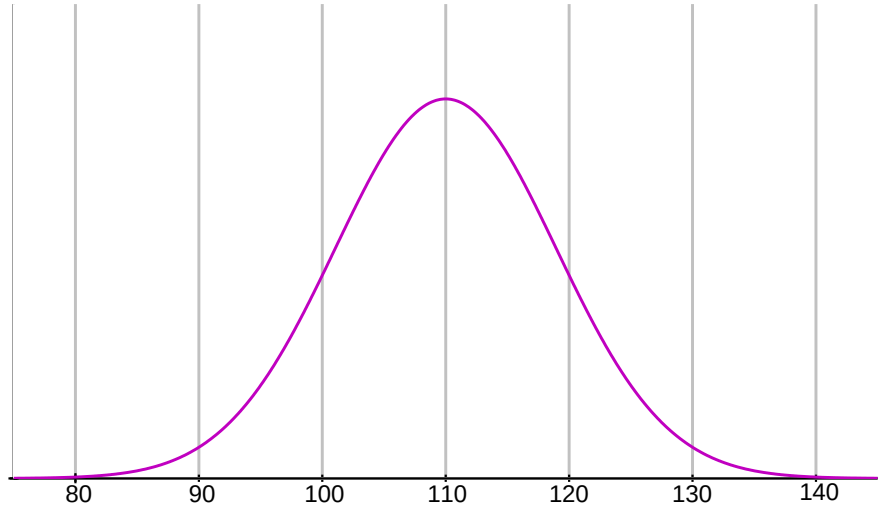
h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

i Anything in the mark scheme which is in square brackets […] is not required for the mark to be earned, but if present it must be correct.

Question		Answer	Marks	Guidance
1	(i)	The population is fluctuating The overall level is staying about the same in the long term The period of the fluctuations is about 10 years	**B1** **B1**	Any two different sensible comments. Accept one correct comment about the minimum or maximum or range of the population.
			[2]	
	(ii)	About 28. 12 values are above 28 and 12 values are below it	**B1** **B1**	Accept from 19 to 35
			[2]	
	(iii)	Population in 1887: 80 Population in 1871: 10 Increase = $\frac{80-10}{10}\times 100\%$ 700%	 **B1** **M1** **A1**	 Both values. Accept 9 FT from 1871 value FT
			[3]	

1	**(iv)**	The badgers' population may be fluctuating A different method was used so the results may not be comparable	**B1** **B1**	Any two sensible answers
			[2]	

Question		Answer	Marks	Guidance
2	(i)		**B1** **B1** **B1**	Bell shaped curve Centred on 110 Horizontal scale
			[3]	
	(ii)	100 is 1 sd below mean Proportion below 100 is (15.87%,) approximately 16%	**M1** **A1**	May be implied by proportion
			[2]	
		Alternative		
		In a Normal distribution approximately ⅔ of values lie within 1 sd of mean	**M1**	Or 68%
		So by symmetry $\frac{1}{3} \div 2 = \frac{1}{6}$ or about 17% are below 100.	**A1**	Or 16%
2	**(iii)**	(2 × 99 + 72 × 105 + 41 × 115 + 2 × 125 + 2 × 145 + 188) ÷ 120	**M1**	

Question		Answer	Marks	Guidance
		$\frac{13201}{120}$ = 110.008... □ 110	A1	
			[2]	
2	(iv)	2 out of 120 = 1.67%	B1	Accept 1.666…
			[1]	
	(v)	The distribution of train times is not Normal.	B1	
			[1]	

Question		Answer	Marks	Guidance
3	(i)	Cluster	B1	
			[1]	
	(ii)	She is drawing a conclusion from quite a small sample. The sample is not random, The sample may not be representative of the public The word "exactly" is not appropriate. You can never "prove" anything by statistics.	B1 B1	Any 2 sensible comments They must be different.
			[2]	
	(iii)	(e) The proportions of students in the 3 groups are the same in the 4 universities	B1	cao
			[1]	

3 (iv)

Expected frequency, f_e	Too light	About right	Too harsh	Total
A	$\frac{80\times40}{160}=20$	**7.5**	**12.5**	**40**
B	17	6.375	10.625	**34**
C	**20**	**7.5**	**12.5**	**40**
D	23	8.625	14.375	**46**
Total	**80**	**30**	**50**	**160**

Table 3.2 Expected frequencies

B1 3 correct entries

B1 All entries correct

$X^2 = \frac{(20-30)^2}{20} + \ldots$

M1 Attempt at correct method. May be implied by at least one correct number.

= 5.0000 + **0.8333** + **4.5000**

\+ 4.7647 + 2.0613 + 2.7191

\+ **5.0000** + **0.8333** + **4.5000**

\+ 5.2609 + 0.2192 + 6.4446 (all rounded to 4 dp)

= 42.1 (to 3sf)

A1 All correct cao but accept 4.5 and 5 with no zeros

[4]

3	**(v)**	$\nu = (4-1)\times(3-1) = 6$	**M1**	
		Critical value at the 5% significance level is 12.59	**A1**	
		Since 42.1 > 12.59, H_0 is rejected.	**M1**	Comparison between their value of X^2 and their critical value
		The evidence suggests that the proportions are not the same (at the 4 universities).	**A1**	cao with no FT
			[4]	

Question		Answer	Marks	Guidance
4	(i)	Egypt: Population = 97 041 072 , Land area = 1 001 450 km^2	B1	Both figures seen
		Population density $= \frac{97041072}{1001450} = 96.9$ people per km^2	B1	Accept 97, 100 or no rounding
			[2]	
	(ii)	The land area is less than 0.5 km^2	B1	Accept It's area is very small Accept "Less than 1 km^2 "
			[1]	
	(iii)	Monaco: Population = 30 645, Land area = 2 km^2	B1	Both figures seen
		2 km^2 means between 1.5 km^2 and 2.5 km^2	M1	Complete method attempted
		$\frac{30645}{2.5} <$ Population density $< \frac{30645}{1.5}$		Accept $\frac{30645}{2} <$ density $< \frac{30645}{1.5}$
		12258 < Population density < 20430		
		The figure of 19 250 lies within this range.	A1	cao
			[3]	
		Alternative for last 2 marks		
		$\frac{30645}{19250}=1.59$	M1	Complete method attempted
		1.59 rounds to 2	A1	cao

Question		Answer	Marks	Guidance
5	(i)	C2 = 40969443, E2 = 53440 $\Rightarrow$ Q2 = $\frac{53440 \times 1000000}{40969443}$ = 1304.4	B1	
		It is the (average) annual electricity consumption in kWh per person (in Algeria).	B1	Units required
			[2]	
	(ii)	Removing all those countries where there is no information in either column C or column E (or both), eg Western Sahara.	B1	Accept other sensible suggestions
			[1]	
	(iii)	Iceland 52921.7	B1	
		Liberia 8.3	B1	
		Liberia is a poor country.	B1	Any sensible statement eg Liberia is a warm country and so people spend less on heating.
			[3]	

	(iv)	Q and D 0.0835 There is no obvious reason for association between land area and electricity use.	**B1**	Allow 1 mark for each plausible reason SC Allow 1 mark for no plausible reasons but correct allocation of correlation coefficients
		Q and J -0.429 Most of the countries with high birth rates are poorer so there could be a negative association between birth rate and electricity consumption per person.	**B1**	
		Q and L 0.638 People in richer countries tend to use more electricity	**B1**	
			[3]	

<table>
<tr><th colspan="2">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(i)</td><td>They are the first countries in each of the regions.</td><td>B1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>[1]</td><td></td></tr>
<tr><td></td><td>(ii)</td><td>
<table>
<tr><th>Country</th><th>Birth rate</th><th>Birth rate rank, x_i</th><th>Population growth rate</th><th>Growth rate rank, y_i</th><th>$d_i = x_i - y_i$</th><th>d_i^2</th></tr>
<tr><td>Algeria</td><td>22.2</td><td>4</td><td>1.7</td><td>5</td><td>-1</td><td>1</td></tr>
<tr><td>Angola</td><td>44.2</td><td>1</td><td>3.52</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>Belize</td><td>24</td><td>3</td><td>1.8</td><td>4</td><td>-1</td><td>1</td></tr>
<tr><td>Bermuda</td><td>11.3</td><td>9</td><td>0.45</td><td>7</td><td>2</td><td>4</td></tr>
<tr><td>Argentina</td><td>16.7</td><td>6</td><td>0.91</td><td>6</td><td>0</td><td>0</td></tr>
<tr><td>Afghanistan</td><td>37.9</td><td>2</td><td>2.36</td><td>2</td><td>0</td><td>0</td></tr>
<tr><td>Russia</td><td>11</td><td>10</td><td>-0.08</td><td>9</td><td>1</td><td>1</td></tr>
<tr><td>Anguilla</td><td>12.5</td><td>8</td><td>1.97</td><td>3</td><td>5</td><td>25</td></tr>
<tr><td>Albania</td><td>13.2</td><td>7</td><td>0.31</td><td>8</td><td>-1</td><td>1</td></tr>
<tr><td>American Samoa</td><td>19.6</td><td>5</td><td>-1.3</td><td>10</td><td>5</td><td>25</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total</td><td>0</td><td>58</td></tr>
</table>
Table 6.1
</td><td>B1

B1

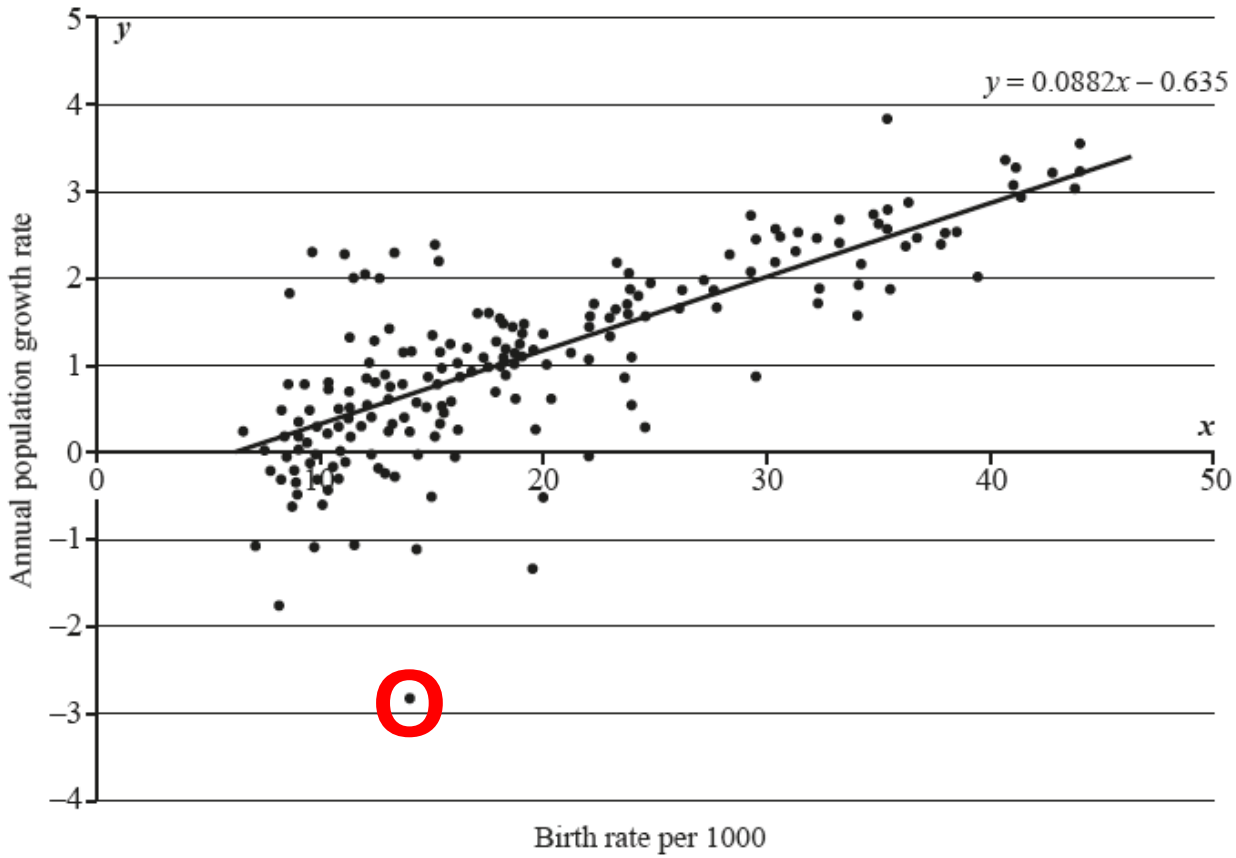
B1

[3]</td><td>Algeria Birth rate & Population growth rate

Birth rate ranks

Total 58 cao</td></tr>
</table>

6	**(iii)**	$r_s = 1 - \frac{6 \times 58}{10\left(10^2 - 1\right)}$ $r_s = 0.6485$	**M1** **A1**	
			[2]	
	(iv)	H_0: There is no association between birth rate and population growth rate.		Accept "no correlation" Accept "Birth rate and population growth rate are independent".
		H_1: There is association between birth rate and population growth rate.	**B1**	Both hypotheses correct
		Critical value for a 2-tail test at the 10% significance level = 0.5636	**M1**	Finding critical value
		0.6485 > 0.5636	**A1**	Comparison
		So H_0 is rejected in favour of H_1. The evidence suggests there is an association between birth rate and population growth rate.	**A1**	Correct conclusion stated in English. Dependent on B1 for the two hypotheses.
			[4]	

6	(v)		B1	
			[1]	
6	(vi)	Movement of population, either emigration or immigration	B1	
			[1]	

	(vii)	(7.2, 0) A birth rate below 7.2 would result in a decreasing population	**M1** **A1**	
			[2]	
	(viii)	It would involve extrapolation to a region where there are no data	**B1**	
			[1]	

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