Mark Scheme (Results)

October 2020

Pearson Edexcel GCE Further Mathematics

Advanced Subsidiary Level

in Further Statistics 1

Paper 8FM0_23

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 40.
2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $\ast$ The answer is printed on the paper
- The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses <u>and indicates which response they wish to submit</u>, examiners should mark this response.
If there are several attempts at a question <u>which have not been crossed out</u>, examiners should mark the final answer which is the answer that is the <u>most complete</u>.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

Question	Scheme	Marks	AOs
1(a)	$X \sim \mathrm{Po}(7.2)$	M1	3.4
	$\mathrm{P}(X = 7) = 0.14858\ldots$ awrt **0.149**	A1	1.1b
		(2)	
(b)	$Y \sim \mathrm{Po}(19.2)$	M1	3.3
	$[\mathrm{P}(Y > 28) =]\ 1 - \mathrm{P}(Y \le 28) = 1 - 0.9780\ldots = 0.02199\ldots$ **0.022***	A1*	1.1b
		(2)	
(c)(i)	$[100 \times 0.022]$ awrt **2.2**	B1	1.1b
		(1)	
(ii)	$\sqrt{100(0.022)(1-0.022)}$	M1	1.1b
	$= 1.466\ldots$ awrt **1.47**	A1	1.1b
		(2)	
(iii)	$\mathrm{B}(100, 0.022) \to \mathrm{Po}(2.2)$	M1	3.4
	$\mathrm{P}(W \ge 6) = 1 - \mathrm{P}(W \le 5)$ $[= 1 - 0.9750\ldots]$	M1	1.1b
	$= 0.02490\ldots$ awrt **0.0249**	A1	1.1b
		(3)	
			(10 marks)

Notes

(a)	**M1:** Writing or using Po(7.2) **A1:** awrt 0.149
(b)	**M1:** Writing or using Po(19.2) **A1*:** cso given answer with correct probability statement (e.g. $1 - \mathrm{P}(Y \le 28)$) and no incorrect working seen
(c)(i)	**B1:** awrt 2.2 (isw once awrt 2.2 is seen)
(c)(ii)	**M1:** Correct expression including square root **A1:** awrt 1.47 Watch out for $\sqrt{2.2} = 1.483...$ which is M0A0
(iii)	**M1:** Approximating binomial (100, 0.022) with Po(2.2) [may be seen in (i) or (ii)] **M1:** Using $1 - \mathrm{P}(W \le 5)$ from Poisson distribution **A1:** awrt 0.0249 Note: Using Binomial distribution 1 – 0.9765588… = 0.02344…scores M0M0A0

Question	Scheme	Marks	AOs
2(a)	H_0: There is no association between the hand and the number of heads H_1: There is an association between the hand and the number of heads	B1	2.5
	$\begin{array}{c\|c\|c\|c\|c} & \mathbf{0} & \mathbf{1} & \mathbf{2} & \mathbf{3} \\ \hline \mathbf{E} & \dfrac{100\times 20}{200} = 10 & \dfrac{100\times 64}{200} = 32 & \dfrac{100\times 78}{200} = 39 & \dfrac{100\times 38}{200} = 19 \end{array}$	M1 A1	1.1b 1.1b
	$\chi^2 = \sum\frac{(O-E)^2}{E} = \frac{(7-10)^2}{10} + \frac{(13-10)^2}{10} + ... + \frac{(16-19)^2}{19}$	M1	1.1b
	= 3.7714…. awrt **<u>3.77</u>**	A1	1.1b
	Degrees of freedom [= (4 – 1) × (2 – 1)] = 3 $\chi^2_{3,0.05} = 7.815$	M1	3.1b
	(Do not reject H_0.) There is not enough evidence to suggest an association between the hand flipping the coin and the number of heads.	A1	2.2b
		(7)	
(b)	B(3, 0.5)	B1	3.3
		(1)	
(c)	H_0: B(3, 0.5) is a suitable model H_1: B(3, 0.5) is not a suitable model	B1ft	3.4
	$\begin{array}{c\|c\|c\|c\|c} & \mathbf{0} & \mathbf{1} & \mathbf{2} & \mathbf{3} \\ \hline \mathbf{E} & 200\times P(X=0) = 25 & 200\times P(X=1) = 75 & 200\times P(X=2) = 75 & 200\times P(X=3) = 25 \end{array}$	M1 A1	2.1 1.1b
	$\chi^2 = \sum\frac{(O-E)^2}{E} = \frac{(20-25)^2}{25} + \frac{(64-75)^2}{75} + \frac{(78-75)^2}{75} + \frac{(38-25)^2}{25}$	M1	1.1b
	= 9.493…. awrt **<u>9.49</u>**	A1	1.1b
	[df = 3] $\chi^2_{3,0.1} = 6.251$	M1	3.1b
	(Reject H_0) B(3, 0.5) is <u>not a suitable model</u> for the number of heads.	A1	3.5a
		(7)	
			(15 marks)

Notes	
(a)	**B1:** For both hypotheses correct with at least one in context. **M1:** For attempt at $\frac{\text{row total} \times \text{column total}}{\text{grand total}}$ (may be implied by one correct expected frequency). Working may be seen in table. **A1:** All correct expected frequencies

<table>
<tr><td></td><td>M1: For applying $\sum\frac{(O-E)^2}{E}$ ft their values
A1: awrt 3.77
M1: For using degrees of freedom to set up χ^2 model
A1: Correct conclusion in context with all other marks scored.</td></tr>
<tr><td>(b)</td><td>B1: B(3, 0.5)

Allow a complete probability distribution with labels
<table><tr><td>x</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>P(X = x)</td><td>0.125</td><td>0.375</td><td>0.375</td><td>0.125</td></tr></table></td></tr>
<tr><td>(c)</td><td>B1ft: For both hypotheses correct. Must have binomial and (3, 0.5) or ft their distribution in part (b)
M1: For attempt at expected frequencies using their distribution from part (b) (may be implied by one correct or correct ft expected frequency)
A1: All correct expected frequencies
M1: For applying $\sum\frac{(O-E)^2}{E}$ ft their values
A1: awrt 9.49
M1: For using degrees of freedom to set up χ^2 model
A1: Correct conclusion in context with all other marks scored.</td></tr>
</table>

Question	Scheme	Marks	AOs
3	$\Sigma p = 1 \rightarrow k + \frac{k}{2} + \frac{k}{3} + \frac{m}{12} + \frac{m}{18} = 1$ $\Sigma px = 3.8 \rightarrow k + \frac{k}{2}(2) + \frac{k}{3}(3) + \frac{m}{12}(6) + \frac{m}{18}(9) = 3.8$	M1	3.1a
	$\frac{11k}{6} + \frac{5m}{36} = 1$ $[= 66k + 5m = 36]$	A1	1.1b
	$3k + m = 3.8$	A1	1.1b
	Solving simultaneously to eliminate one variable	dM1	1.1b
	$k = \frac{1}{3}$ and $m = \frac{14}{5}$	A1	1.1b
	$\mathrm{E}(X^2) = 1^2 \times k + 2^2 \times \frac{k}{2} + 3^2 \times \frac{k}{3} + 6^2 \times \frac{m}{12} + 9^2 \times \frac{m}{18} [= 23]$	M1	1.1b
	$\mathrm{Var}(X) = 23 - 3.8^2$		
	= **<u>8.56</u>**	A1	1.1b
			(7 marks)

Notes

M1: Attempt at both required equations with at least one term in *k* and one term in *m* correct
A1: Correct equation using $\Sigma p = 1$
A1: Correct equation using $\Sigma px = 3.8$
dM1: (dep on 1st M1) Solving simultaneously (may be implied by one correct value found)
A1: both values correct (may be implied by correct answer)
M1: Attempt to find $\mathrm{E}(X^2)$ using their value of *k* and their value of *m* with at least 3 correct products or correct ft products   Note: $\mathrm{E}(X^2) = 6k + 7.5m$
A1: 8.56 cao

Question	Scheme	Marks	AOs
4(a)	[$X \sim \text{Po}(8)$ $Y \sim \text{Po}(3)$] [$X + Y \sim$] Po (11)	B1	3.3
	The number of cyclists travelling eastbound is independent of the number of cyclists travelling westbound.	B1	3.5b
		(2)	
(b)	$\dfrac{\text{P}(X = 11) \times \text{P}(Y = 1) + \text{P}(X = 12) \times \text{P}(Y = 0)}{\text{P}(X + Y = 12)}$	M1 M1	2.1 1.1b
	= 0.1204… awrt **<u>0.120</u>**	A1	1.1b
		(3)	
(c)	H_0: $\lambda = 11$ or $\mu = 22$ H_1: $\lambda < 11$ or $\mu < 22$	B1	2.5
	$(E + W) \sim \text{Po}(22)$ $\text{P}(E + W \leq 14)$ [= awrt 0.048]	M1	3.3
	(Reject H_0.) There is evidence that the **rate**(oe) of **cyclists**(oe) has decreased.	A1	2.2b
		(3)	
			(8 marks)

Notes

(a)	**B1:** Correct model **B1:** Correct modelling assumption in context (must mention cyclists oe)
(b)	**M1:** Attempt at ratio expression with denominator $\text{P}(X + Y = 12)$ (may see 0.10942…) **M1:** Probability expression for numerator (may be implied by 0.01317…) **A1:** awrt 0.120 accept 0.12 with correct working seen Alternative use of binomial: **M1:** Use of $C \sim \text{B}(12, \frac{8}{11})$ **M1:** $\text{P}(C \geq 11) = 1 - \text{P}(C \leq 10)$ **A1:** awrt 0.120 accept 0.12 with correct working seen
(c)	**B1:** Both hypotheses with λ or μ **M1:** Using Po(22) to calculate $\text{P}(E + W \leq 14)$ **A1:** A fully correct conclusion with awrt 0.048 or CR: $E + W \leq 14$ drawing an inference in context.

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