



Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE

Advanced Subsidiary Level

Further Mathematics (8FM0)

Paper 23 Further Statistics 1

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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 \checkmark 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
 - * The answer is printed on the paper
 - \square 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 and indicates which response they wish to submit, examiners should mark this response.

If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

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, alternative 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.

Qu	Scheme	Marks	AO
1(a)	H_0 : There is <u>no association</u> between <u>age</u> range and preferred <u>game</u> H_1 : There <u>is</u> an <u>association</u> between <u>age</u> range and preferred <u>game</u>	B1 (1)	1.2
(b)	(i) $\frac{29 \times 28}{100} = \underline{8.12}$ (ii) $\frac{42 \times 35}{100} = \underline{14.7}$	M1 A1 (2)	1.1b 1.1b
(c)	[Since (b) (i) > 5 there is no pooling so df = (3-1) × (3-1) =] 4	B1 (1)	1.1b
(d)	$\chi_4^2(0.05) = \underline{9.488}$ [The test is significant so reject H_0 :] Sharma's <u>belief</u> is <u>not supported</u> / there is significant evidence of an association between <u>age</u> range and computer <u>game</u> preference.	B1ft B1 (2)	3.4/ 1.1b 2.2b
		(6 marks)	
Notes			
(a)	B1 for both hypotheses in context must mention independence/dependence or no association/association must mention <u>age</u> and <u>game</u> at least once Do not allow e.g. ' H_0 : games sold appeal equally to all age ranges' Use of 'correlation', 'link', 'relationship', 'connection' is B0 but allow for 2 nd B1 in (d) ignore comments about sales		
(b)	M1 for one correct expression or correct value. A1 for both correct values (correct to 1 dp) . Accept 8.1		
(c)	B1 for 4 cao		
(d)	1 st B1ft for awrt 9.488 or ft their df for a 5% critical value may see $\chi_3^2(0.05) = 7.815$ $\chi_2^2(0.05) = 5.991$ $\chi_7^2(0.05) = 14.067$ $\chi_8^2(0.05) = 15.507$ 2 nd B1 Indep of hypotheses but dep on cv < 11.542 for correct statement in context about Sharma's belief condone e.g ' <u>games</u> sold do not appeal equally to all <u>age</u> ranges' for a contextual statement must mention <u>age</u> and <u>game</u> B0 for contradictory statements e.g. "test is not significant so belief is not supported"		

Qu	Scheme	Marks	AO
2(a)	Since <u>accidents</u> occur <u>randomly/independently</u> / at a <u>constant/average rate</u>	B1 (1)	2.4
(b)(i)	[A = no. of accidents in a month. $A \sim \text{Po}(2.7)$ [$P(A \geq 3) = 1 - P(A \leq 2) = 1 - 0.49362 \dots = 0.50637 \dots$] awrt 0.506	B1 (1)	1.1b
(ii)	[T = no. of accidents in a 3-month period.] $T \sim \text{Po}(3 \times 2.7 = [8.1])$ [$P(T \leq 10)] = 0.805837 \dots =$ awrt 0.806	M1 A1 (2)	3.3 1.1b
(iii)	[M = no. of months with no accidents.] $M \sim B(8, e^{-2.7})$ $M \sim B(8, 0.067(2) \dots)$ $P(M \geq 2) = 1 - P(M \leq 1)$ $= 1 - 0.903542 \dots = 0.096457 \dots =$ awrt 0.0965	M1 A1 M1 A1 (4)	3.3 1.1b 3.4 1.1b
(c)	For a Poisson model accidents (events) must <u>occur singly/independently</u> so manager should record as <u>one</u> accident	B1 (1)	3.5b/2. 4
(d)	$H_0 : \lambda = 2.7$ (or $\mu = 32.4$) $H_1 : \lambda < 2.7$ (or $\mu < 32.4$) [Y = no. of accidents in a year.] $Y \sim \text{Po}(32.4)$ $P(Y \leq 22) = 0.03512 \dots$ [Significant result so reject H_0] there is evidence to <u>support</u> the manager's <u>claim</u> / there is evidence that the number of <u>accidents per month</u> has <u>decreased</u>	B1 M1 A1 A1 (4)	2.5 3.3 3.4 2.2b
		(13 marks)	
Notes			
(a)	B1 for a suitable reason picking up the underlined words from the context.		
(b)(i)	B1 for awrt 0.506		
(ii)	M1 for selecting the Po(8.1) model (sight of or implied by a correct answer) A1 for awrt 0.806		
(iii)	1 st M1 for selecting a suitable binomial model e.g. $B(8, p)$ or $B(n, 0.067 \dots)$ 1 st A1 for the correct model ($p = e^{-2.7}$ or 0.067 or better) seen or implied by a correct answer. 2 nd M1 for using their binomial model to attempt $P(M \geq 2)$ <u>or</u> $1 - P(M \leq 1)$ awrt 0.0964 is evidence for this M1 mark 2 nd A1 for awrt 0.0965		
(c)	B1 for stating the accidents (events) “occur singly” <u>or</u> accidents (events) are “independent” AND should record as <u>one</u> accident		
(d)	B1 for both correct hypotheses in terms of λ or μ (accept $\mu = 2.7$ etc) M1 for selecting the correct model (sight of or implied by the correct probability) $P(Y = 22) =$ awrt 0.0129 is evidence for M1 1 st A1 for awrt 0.035 (accept 0.04 if $P(Y \leq 22)$ and $\text{Po}(32.4)$ are explicitly seen) 2 nd A1 dep on M1A1 indep of hyp's for a correct conclusion in context number of accidents reduced is A0 must be rate / per month / average number		

Qu	Scheme	Marks	AO											
3	$[E(X) =] -1 \times p + 0 + 1 \times p + 3 \times 0.3 + 7r$ <u>or</u> $0.9 + 7r [= 1.95]$ $[7r = 1.05 \text{ so}]$ <u>$r = 0.15$</u> $[\text{Sum of probs} = 1]$ $2p + 0.3 + 2r = 1$ (o.e.) $p = 0.2$	M1	3.1a											
	[Let $Y = \sqrt{X + 1}$]	A1	1.1b											
	<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td>y</td> <td>0</td> <td>1</td> <td>$\sqrt{2}$</td> <td>2</td> <td>$\sqrt{8}$ or $2\sqrt{2}$</td> </tr> <tr> <td>P(Y = y)</td> <td>"0.2"</td> <td>"0.15"</td> <td>"0.2"</td> <td>0.3</td> <td>"0.15"</td> </tr> </table> $[E(Y) =] 0 + '0.15' + '0.2' \sqrt{2} + 2 \times 0.3 + '0.15' \times \sqrt{8}$ $= 0.75 + 0.5\sqrt{2}$	y	0	1	$\sqrt{2}$	2	$\sqrt{8}$ or $2\sqrt{2}$	P(Y = y)	"0.2"	"0.15"	"0.2"	0.3	"0.15"	M1
y	0	1	$\sqrt{2}$	2	$\sqrt{8}$ or $2\sqrt{2}$									
P(Y = y)	"0.2"	"0.15"	"0.2"	0.3	"0.15"									
		A1cao	1.1b											
(6 marks)														
Notes														
	1 st M1 for an attempt at an expression for E(X) at least 3 correct non-zero products 1 st A1 for $r = 0.15$ oe 2 nd M1 for using sum of probabilities = 1 to form an equation for p (ft their value or letter r) 2 nd A1ft for $p = 0.2$ oe or ft their r for $p = \frac{0.7 - 2 \times "0.15"}{2}$ (provided p is a probability) 3 rd M1 for attempt at E(Y) with at least 2 correct y values and products ft their p and r 3 rd A1 cao allow fraction or decimal, also allow $\frac{3 + 2\sqrt{2}}{4}$													

Qu	Scheme	Marks	AO																							
4(a)	e.g. The <u>probability</u> of an arrow hitting the target is <u>constant</u>	B1	1.2/3.5b																							
	e.g. The arrows are shot <u>independently</u>	B1	1.2/3.5b																							
(b)	$\hat{p} = \frac{0 \times 1 + 1 \times 10 + 2 \times 30 + 3 \times 34 + 4 \times 17 + 5 \times 4 + 6 \times 2 + 7 \times 0 + 8 \times 2}{100 \times 8}$ $= \left[\frac{2.88}{8} \right] = \underline{\underline{0.36}}$	(2) M1	1.1b																							
		A1	1.1b																							
(c)	[Let $X \sim B(8, \text{awrt "0.36"})$ $P(X = 2) = 0.24936\dots$ or $P(X = 5) = 0.08876\dots$ $(E(2)) = \text{awrt } \underline{\underline{24.94}}$ (24.93~24.95) or $(E(5)) = \text{awrt } \underline{\underline{8.88}}$ (8.87~8.89) For using Sum of Expected frequencies = 100 (accept awrt 100.01)	M1	3.4																							
		A1 B1ft	1.1b 1.1b																							
(d)(i)	Need to pool some values <u>to make all $E_i > 5$</u> [Needn't specify] <u>Two constraints AND p was estimated.</u> ["2 constraints" $\leftarrow 5 - 2 = 3$]	(3) B1	1.1b																							
		B1	2.4																							
(ii)	H_0 : Binomial is a good model for these data H_1 : Binomial is not a suitable model for these data	B1	2.5																							
		<table border="1"> <thead> <tr> <th>Hits</th> <th>0 or 1</th> <th>2</th> <th>3</th> <th>4</th> <th>...5</th> </tr> </thead> <tbody> <tr> <td>Ex freq</td> <td>15.48</td> <td>"24.94"</td> <td>28.05</td> <td>19.73</td> <td>"11.80"</td> </tr> <tr> <td>$\frac{(O_i - E_i)^2}{E_i}$</td> <td>$\frac{(11-15.48)^2}{15.48}$ =1.30</td> <td>$\frac{(30-24.94)^2}{24.94}$ =1.03</td> <td>$\frac{(34-28.05)^2}{28.05}$ =1.26</td> <td>$\frac{(17-19.73)^2}{19.73}$ =0.38</td> <td>$\frac{(8-11.80)^2}{11.80}$ =1.22</td> </tr> <tr> <td>$\frac{O_i^2}{E_i}$</td> <td>$\frac{11^2}{15.48} = 7.82$</td> <td>$\frac{30^2}{24.94} = 36.09$</td> <td>$\frac{34^2}{28.05} = 41.21$</td> <td>$\frac{17^2}{19.73} = 14.65$</td> <td>$\frac{8^2}{11.80} = 5.42$</td> </tr> </tbody> </table>	Hits	0 or 1	2	3	4	...5	Ex freq	15.48	"24.94"	28.05	19.73	"11.80"	$\frac{(O_i - E_i)^2}{E_i}$	$\frac{(11-15.48)^2}{15.48}$ =1.30	$\frac{(30-24.94)^2}{24.94}$ =1.03	$\frac{(34-28.05)^2}{28.05}$ =1.26	$\frac{(17-19.73)^2}{19.73}$ =0.38	$\frac{(8-11.80)^2}{11.80}$ =1.22	$\frac{O_i^2}{E_i}$	$\frac{11^2}{15.48} = 7.82$	$\frac{30^2}{24.94} = 36.09$	$\frac{34^2}{28.05} = 41.21$	$\frac{17^2}{19.73} = 14.65$	$\frac{8^2}{11.80} = 5.42$
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	Test statistic = 5.188692... awrt <u>5.19</u> (allow awrt 5.18) CV $\chi_3^2(5\%) = 7.815$ [Do not rej H_0] Data is compatible with Misha's <u>belief</u> /Binomial model is suitable	A1	1.1b																							
		B1	1.1b																							
		A1 (6)	2.2b																							
(15 marks)																										
Notes																										
(a)	1 st B1 for one suitable comment which must mention "arrows"/ "shots" / "hit" / "target" <u>or</u> for both comments not in context 2 nd B1 for both suitable comments which must mention "arrows"/ "shots"/"hit" / "target" at least once																									
(b)	M1 for correct attempt at mean or \hat{p} (allow at least 3 correct non-zero products seen) A1 for 0.36 (sight of 2.88 scores M1 and the A mark when divided by 8) (may be seen in (c))																									
(c)	M1 for sight or use of a correct binomial model to find either prob (ft their 0.36) A1 for either correct expected frequency B1ft for two positive values of r and s such that $r + s = 33.82$ or 33.81																									
(d)(i)	1 st B1 for mention of the need to pool <u>since $E_i < 5$</u> or <u>to get $E_i > 5$</u> 2 nd B1 for mention of 2 constraints because p is estimated/calculated (from data)																									
(ii)	1 st B1 for both hypotheses correct 1 st M1 for correct pooling (0&1) <u>and</u> (...5) (ft their r and s) (may be implied by awrt 5.18) 2 nd M1 for correct use of test statistic (at least one correct calc to at least 2 sf from 3 rd or 4 th row) 1 st A1 for awrt 5.19 (accept awrt 5.18, awrt 5.20) 2 nd B1 for 7.815 (or better) [NB p -value = 0.1586 ... and is B0] 2 nd A1 dep on both M marks for a correct conclusion with "belief" or "binomial" e.g B(8, 0.36) is a suitable model is A1																									

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