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 $\surd$ 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
- ⌐ 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, 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.

Qu	Scheme	Marks	AO
1(a)	H_0 : There is no association between age range and preferred game H_1 : There is an association between age range and preferred game	B1 (1)	1.2
(b)	(i) $\frac{29\times 28}{100}$ = **8.12** (ii) $\frac{42\times 35}{100}$ = **14.7**	M1 A1 (2)	1.1b 1.1b
(c)	[Since (b) (i) > 5 there is no pooling so df = $(3-1)\times(3-1)$ =] **4**	B1 (1)	1.1b
(d)	$\chi_4^2(0.05)$ = **9.488** [The test is significant so reject H_0 :] Sharma's belief is not supported / there is significant evidence of an association between age range and computer game 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 age and game 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 2nd 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)	1st B1ft for awrt 9.488 or ft their df for a 5% critical value may see $\chi_3^2(0.05)=7.815$ $\chi_2^2(0.05)=5.991$ $\chi_7^2(0.05)=14.067$ $\chi_8^2(0.05)=15.507$ 2nd B1 **Indep of hypotheses but dep on cv < 11.542** for correct statement in context about Sharma's belief condone e.g 'games sold do **not** appeal equally to all age ranges' for a contextual statement must mention age and game B0 for contradictory statements e.g. "test is not significant so belief is not supported"

Qu	Scheme	Marks	AO
2(a)	Since accidents occur randomly/independently / at a constant/average rate	B1 (1)	2.4
(b)(i)	[A = no. of accidents in a month. A~Po(2.7)]		
	[P($A \geqslant 3$) =1 – P($A \leqslant 2$) = 1 – 0.49362 ..= 0.50637..=] awrt **0.506**	B1 (1)	1.1b
(ii)	[T = no. of accidents in a 3-month period.] T ~Po(3×2.7=[8.1])	M1	3.3
	[P($T \leqslant 10$)] = 0.805837… = awrt **0.806**	A1 (2)	1.1b
(iii)	[M = no. of months with no accidents.] $M \sim$ B(8, $e^{-2.7}$)	M1	3.3
	M ~B(8, 0.067(2)…)	A1	1.1b
	P($M \geqslant 2$) = 1 – P($M \leqslant 1$)	M1	3.4
	= 1 – 0.903542 … = 0.096457… = awrt **0.0965**	A1 (4)	1.1b
(c)	For a Poisson model accidents (events) must occur singly/independently so manager should record as one accident	B1 (1)	3.5b/2.4
(d)	$H_0 : \lambda = 2.7$ (or $\mu = 32.4$) $H_1 : \lambda < 2.7$ (or $\mu < 32.4$)	B1	2.5
	[Y = no. of accidents in a year.] Y~Po(32.4)	M1	3.3
	P($Y \leqslant 22$) = 0.03512…	A1	3.4
	[Significant result so reject H_0]		
	there is evidence to support the manager's claim / there is evidence that the number of accidents per month has decreased	A1 (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)	1st M1 for selecting a suitable binomial model e.g. B(8, p) or B(n, 0.067…)
	1st A1 for the correct model ($p = e^{-2.7}$ or 0.067 or better) seen or implied by a correct answer.
	2nd M1 for using their binomial model to attempt P($M \geqslant 2$) or 1 – P($M \leqslant 1$) awrt 0.0964 is evidence for this M1 mark
	2nd A1 for awrt 0.0965
(c)	B1 for stating the accidents (events) "occur singly" oe or accidents (events) are "independent" **AND** should record as one 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
	1st A1 for awrt 0.035 (accept 0.04 if P($Y \leqslant 22$) and Po(32.4) are explicitly seen)
	2nd 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]	M1	3.1a
	[$7r = 1.05$ so] ***r* = 0.15**	A1	1.1b
	[Sum of probs = 1] $2p + 0.3 + 2r = 1$ (o.e.)	M1	2.1
	***p* = 0.2**	A1ft	1.1b
	[Let $Y=\sqrt{X+1}$]		
	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"		
	[E(Y) =] $0+'0.15'+'0.2'\sqrt{2}+2\times 0.3+'0.15'\times\sqrt{8}$	M1	3.1a
	$= \mathbf{0.75 + 0.5}\sqrt{2}$	A1cao	1.1b
		(6 marks)	

Notes

1st M1 for an attempt at an expression for E(X) at least 3 correct non-zero products

1st A1 for $r = 0.15$ oe

2nd M1 for using sum of probabilities = 1 to form an equation for p (ft their value or letter r)

2nd A1ft for $p = 0.2$ oe or ft their r for $p = \dfrac{0.7-2\times"0.15"}{2}$ (provided p is a probability)

3rd M1 for attempt at E(Y) with at least 2 correct y values and products ft their p and r

3rd A1 cao allow fraction or decimal, also allow $\dfrac{3+2\sqrt{2}}{4}$

Qu	Scheme	Marks	AO
4(a)	e.g. The probability of an arrow **hitting** the **target** is constant	B1	1.2/3.5b
	e.g. The **arrows** are shot independently	B1	1.2/3.5b
		(2)	
(b)	$\hat{p} = \dfrac{0\times1+1\times10+2\times30+3\times34+4\times17+5\times4+6\times2+7\times0+8\times2}{100\times8}$	M1	1.1b
	$= \left[\dfrac{2.88}{8}\right]$ $= \mathbf{0.36}$	A1	1.1b
		(2)	
(c)	[Let X ~B(8, awrt "0.36")]		
	$P(X = 2) = 0.24936\ldots$ or $P(X = 5) = 0.08876\ldots$	M1	3.4
	(E(2)) = awrt **24.94** (24.93~24.95) or (E(5)) = awrt **8.88** (8.87~8.89)	A1	1.1b
	For using Sum of Expected frequencies = 100 (accept awrt 100.01)	B1ft	1.1b
		(3)	
(d)(i)	Need to pool some values to make all $E_i > 5$ [Needn't specify]	B1	1.1b
	Two constraints **AND** p was estimated. ["2 constraints" ⇐ 5 – 2 = 3]	B1	2.4
		(2)	
(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

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
$\frac{O_i^2}{E_i}$	$\frac{11^2}{15.48} = 7.82$	$\frac{30^2}{24.94} = 36.09$	$\frac{34^2}{28.05} = 41.21$	$\frac{17^2}{19.73} = 14.65$	$\frac{8^2}{11.80} = 5.42$

		M1	1.1b/ (2.1)
		M1	1.1b
	Test statistic = 5.188692… awrt **5.19** (allow awrt 5.18)	A1	1.1b
	CV $\chi_3^2(5\%) = 7.815$	B1	1.1b
	[Do not rej H_0] Data is compatible with Misha's belief /Binomial model is suitable	A1 **(6)**	2.2b
		(15 marks)	

Notes

(a) 1st B1 for **one** suitable comment which must mention "arrows"/ "shots" / "hit" / "target" or for **both** comments not in context
2nd 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) 1st B1 for mention of the need to pool since $E_i < 5$ or to get $E_i > 5$
2nd B1 for mention of 2 constraints because p is estimated/calculated (from data)

(ii) 1st B1 for both hypotheses correct
1st M1 for correct pooling (0&1) and (…5) (ft their r and s) (may be implied by awrt 5.18)
2nd M1 for correct use of test statistic (at least one correct calc to at least 2 sf from 3rd or 4th row)
1st A1 for awrt 5.19 (accept awrt 5.18, awrt 5.20)
2nd B1 for 7.815 (or better) [NB p-value = 0.1586 … and is B0]
2nd 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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