Mark Scheme

Summer 2023

Pearson Edexcel GCE

Advanced Subsiduary 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	$E(X) = 0\times r + k + 2\times\frac{k}{2} + 3\times\frac{k}{3} + 4\times\frac{k}{4}$ or $4k$	B1	2.1
	$E(X^2) = k + 2^2\times\frac{k}{2} + 3^2\times\frac{k}{3} + 4^2\times\frac{k}{4}$ or $k + 2k + 3k + 4k$ or $10k$	M1	1.1b
	$\sqrt{\text{Var}(X)} = E(X) \Rightarrow E(X^2) = 2[E(X)]^2$ or $10k - (4k)^2 = (4k)^2$	M1	1.1b
	$10k = 32k^2 \Rightarrow k = \frac{5}{16}$	A1	1.1b
	$\left[\sum \text{probs} = 1 \Rightarrow\right] r + \frac{1}{12}(12k + 6k + 4k + 3k) = 1$ $\left[\Rightarrow r + \frac{25}{12}k = 1\right]$	M1	3.1a
	$r = 1 - \frac{25}{12}\times\frac{5}{16} = \frac{67}{192}$	A1	1.1b
		(6)	

Notes

	B1	for a correct expression for E(X)
	1st M1	for attempting $E(X^2)$ – at least 3 correct non-zero terms
	2nd M1	Use of $\text{Var}(X) = E(X^2) - [E(X)]^2$ to form an expression in k with $\sqrt{\text{Var}(X)} = E(X)$ ft their $10k$ and their $4k$ Must use a consistent expression for $E(X)$ in both side of their equation
	1st A1	for a correct equation for k (e.g. 2TQ) or $k = \frac{5}{16}$ or 0.3125. They may ignore or reject solution of $k = 0$ Allow for $r = 0.349$ or better
	3rd M1	for attempt at an equation in r and k using sum of probs. At least 4 terms correct in terms of k or numerically using their value of k
	2nd A1	for $\frac{67}{192}$ or exact equivalents e.g. $0.3489583\dot{}$ Correct exact answer implies full marks

Qu	Scheme	Marks	AO
2.(a)	$E(RR) = \frac{60\times 60}{150}$ or $E(BB) = \frac{30\times 27}{150}$ or $E(YY) = \frac{60\times 63}{150}$	M1	1.1b
	E(RR) = **24** and E(BB) = **5.4** and E(YY) = **25.2**	A1 **(2)**	1.1b
(b)	[E(BB) > 5 so no need for pooling] $\nu = (3-1)(3-1) = 4$	B1	3.1b
	Critical value: $\chi_4^2(5\%)$ = **9.488**	B1ft	1.1b
	(significant) evidence that the colour of balls is **not** independent)	B1ft **(3)**	2.2b
(c)	$O_i > E_i$ for pairings of the same colour **and** some children may be cheating when selecting the 2nd ball so choice not independent (o.e.)	B1 **(1)**	3.5a
		(6)	

Notes		
(a)	M1	for at least one correct calculation seen
	A1	for all 3 expected frequencies correct, must be exact.
(b)	1st B1	for 4 degrees of freedom
	2nd B1ft	for awrt 9.488 or ft their degrees of freedom for 5% cv
	3rd B1ft	for correct contextual conclusion mentioning "colour" and "independent" Must be consistent with their cv Allow associated instead of not independent
(c)	B1	Stating or indicating that $O_i > E_i$ **and** a suitable reason for the lack of independence that would invalidate the modelling assumption. Such as: • cheating/looking • The first ball being replaced by the child so more likely to be picked again

Qu	Scheme	Marks	AO
3. (a)	[F = no of faults in A m^2] $F \sim \text{Po}(A \times 0.4)$	M1	3.3
	[P($F = 0$) $\Rightarrow$] $0.0907 = e^{-0.4A}$	M1	3.4
	$A =$ **6**	A1	1.1b
		(3)	
(b)	[T = no. of tablecloths with no faults] $T \sim \text{B}(20, 0.0907)$	M1	3.3
	$\text{P}(T > 1) = 1 - \text{P}(T \leqslant 1)$	M1	1.1b
	$= 0.55276\ldots$ = awrt **0.553**	A1	3.4
		(3)	
(c)(i)	[$X \sim \text{B}(100, 0.0907)$]	M1	3.3
	$\text{E}(X) = 100 \times 0.0907 =$ **9.07**	A1	1.1b
(ii)	$\text{Var}(X) = 100 \times 0.0907 \times (1 - 0.0907) = 8.247351$ awrt **8.25**	A1	1.1b
		(3)	
(d)	$X \approx \sim \text{Po}(9.07)$;	M1	3.4
	$\text{P}(X = 10) \approx 0.11947\ldots$ **0.1195** or awrt **0.119**	A1	1.1b
		(2)	
(e)	$\text{H}_0: \lambda = 0.4$ (or $\lambda = 12$) $\text{H}_1: \lambda < 0.4$ (or $\lambda < 12$)	B1	2.5
	[Y = no. of faults from new machine] $Y \sim \text{Po}(12)$	M1	1.1b/3.3
	$\text{P}(Y \leqslant 6) = 0.04582...$	A1	3.4
	[Significant] there is evidence to support the claim	A1	2.2b
		(4)	
(f)	p – value = 0.04582.. awrt **0.0458**	B1ft	1.2
		(1)	
		(16)	

Notes		
(a)	1st M1	for selecting the correct model Po(0.4A)
	2nd M1	for a correct equation - may be implied by a correct answer with no incorrect working
	A1	for $A = 6$ (or awrt 6.0)
(b)	1st M1	for selecting a correct model B(20, 0.0907) used, or seen if only distribution in (b)
	2nd M1	for correctly interpreting "more than 1" to reach $1 - \text{P}(T \leqslant 1)$. May be implied by A1
	A1	for awrt 0.553
(c)(i)	M1	for $X \sim \text{B}(100, 0.0907)$ used, or seen if only distribution in (c). May be implied by correct E(X) or Var(X)
	A1	for 9.07
(ii)	A1	for awrt 8.25 **SC - award M0A1A0 for:** • using $X \sim \text{B}(100, 0.4)$ leading to $\text{E}(X) = 40$, $\text{Var}(X) = 24$ • using $X \sim \text{B}(100, p)$, $0 < p < 1$ and $\text{E}(X) = 100p$, $\text{Var}(X) = 100p(1 - p)$
(d)	M1	for selecting the correct Poisson model – ft their answer to (c)(i)
	A1	for 0.1195or awrt 0.119
(e)	B1	for both hypotheses correct in terms of λ or μ
	M1	for selecting a suitable model. Sight or use of Po(12). May be implied by 1st A1
	1st A1	for a correct probability must be 0.046 or better
	2nd A1	for a correct conclusion in context using "claim" or "rate of faults"
(f)		B1ft for awrt 0.0458 o.e. e.g. 4.58% or ft their answer to 1st A1 in (e)

Qu	Scheme	Marks	AO
4. (a)	H_0: No. of car breakdowns per month follows a Poisson distribution H_1: No. of car breakdowns per month does not follow a Poisson distribution	B1 **(1)**	2.5
(b)	A Poisson distribution will assign some probability to (all) values greater than 5 (o.e.)	B1 **(1)**	2.4
(c)	Need λ: $[\hat{\lambda}=]\dfrac{0\times 12+1\times 11+2\times 19+3\times 14+4\times 3+5\times 1}{(12+11+19+14+3+1)}$ or 1.8 [Under H_0 $X\sim$Po(1.8) $E_1=60\times P(X=1)=17.85(227\ldots)$ $E_2=60\times P(X=2)=16.06(705\ldots)$ $E_{\geqslant 5}=60-\sum_0^4 E_i=2.18(43996\ldots)$	M1 M1 A1 B1ft **(4)**	1.1b 3.4 1.1b 1.1b
(d)	$\dfrac{(11-"17.85\ldots")^2}{"17.85\ldots"}=2.6287\ldots$ or $\dfrac{(14-9.64)^2}{9.64}=1.97195\ldots$ awrt 2.63 and awrt 1.97	M1 A1 **(2)**	1.1b 1.1b
(e)	Need to combine last two columns since E_i are < 5 Degrees of freedom therefore 5 – 2 since mean for Poisson estimated from O_i	B1 B1 **(2)**	1.1a 1.1a
(f)	$\chi_3^2(5\%)=7.815$ (Not significant) insufficient evidence to reject Anja's belief	B1 B1 **(2)**	1.1b 2.2b
		(12)	

Notes

(a)	B1	correct hypotheses mentioning "breakdowns" and "Poisson". Po(1.8) o.e. is B0
(b)	B1	for a suitable reason mentioning the Poisson distribution taking values beyond 5 e.g. sample space for Poisson being [0, ∞)
(c)	1st M1	for an expression for the mean with least 3 correct products and correct denominator M0 if they have found λ by working backwards from $P(X=0)\Rightarrow 60e^{-\lambda}=9.92$
	2nd M1	for a correct method for finding E_1 or E_2 (implied by one correct value)
	1st A1	for awrt 17.85 and awrt 16.07
	B1ft	for awrt 2.18, or using 60 – (sum of their E_i) or $60\times(1-P(X\leq 4))$
(d)	M1	for either correct expression (ft their E_1)
	A1	for awrt 2.63 and awrt 1.97
(e)	1st B1	for explaining need to pool columns since $E_i < 5$ allow candidates describing combining last three columns as long as they say $E_i < 5$
	2nd B1	for mentioning mean/rate/parameter/λ estimated from O_i and 2 constraints
(f)	1st B1	for correct cv of 7.815 (or better)
	2nd B1	for correct conclusion in context mentioning "breakdowns" and "Poisson" Allow equivalent words for belief, such as "theory" etc. Must be consistent with their cv Allow Po(1.8) in conclusion instead of Poisson

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