Pearson Edexcel

Mark Scheme (Results)

November 2021

Pearson Edexcel GCE
In AS 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 √ 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 <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.

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Question	Scheme	Marks	AOs
1(a)	$r = 125 \times \mathrm{P}(X = 2)$ **or** $s = 125 \times (1 - \mathrm{P}(X \le 4))$ **or** $s = 125 - (24.42 + 40.70 + \text{"their } r\text{"} + 17.45 + 6.73)$ **or** $r = 125 - (24.42 + 40.70 + \text{"their } s\text{"} + 17.45 + 6.73)$	M1	3.4
	r = awrt 33.07 s = awrt 2.63	A1	1.1b
		(2)	
(b)	H_0: B(40, 0.04) is a suitable model H_1: B(40, 0.04) is not a suitable model	B1	3.4
	Cells are combined when expected frequencies < 5 therefore combine last 2 cells	M1	2.1
	$\chi^2 = \sum \frac{(15-24.42)^2}{24.42} + \frac{(35-40.7)^2}{40.7} + \ldots + \frac{(15-(6.73+\text{""}2.63\text{""}))^2}{(6.73+\text{""}2.63\text{""})}$	M1	1.1b
	= 9.752	A1	1.1b
	Degrees of freedom = 5 – 1 = 4	B1	1.1b
	There is significant evidence to reject H_0 as 9.752 > 9.488, therefore Amodita's model is not supported	A1cao	3.5a
		(6)	
(c)	$\frac{[0\times15+]1\times35+2\times38+3\times22+4\times10+5\times5}{125\times40}$ [= 0.0484]	M1	1.1b
	p = 0.0484	A1	1.1b
		(2)	
			(10 marks)

Notes:

(a)	**M1:**	A correct method for finding r or s Implied by a correct value for s or r
	A1:	33.07 and 2.63 – both correct and to two decimal places
(b)	**B1:**	For both hypotheses correct. Must include B(40, 0.04) in at least one hypothesis oe
	M1:	For combining the last 2 cells May be implied by awrt 9.75/9.76 but not d of f = 4
	M1:	Correct method for finding the value of χ^2. If no method shown it must be correct (allow M0 M1 for awrt 10.1)
	A1:	awrt 9.75/9.76
	B1:	For use of one constraint. eg sight of 5 – 1 = 4 **or** just 4 if working shows cells not combined or χ^2 value of awrt 9.8 **or** allow just 5 if working shows cells not combined or χ^2 value of awrt 10.1
	A1cao**:**	dep on both M marks awarded. Correct conclusion in context must have sight of CV 9.488 (condone 9.49) Allow Binomial B(40, 0.04) is not a suitable model. NB condone missing distribution if already penalised in hypotheses
(c)	**M1:**	Using the data to find a value of p
	A1:	Allow any of 0.048, 0.05 if working shown.

Question	Scheme	Marks	AOs
2(a)	$P(R \geq 23) = 0.8517...$ awrt **0.852**	B1	1.1b
		(1)	
(b)	$R \sim Po(28)$ $A \sim Po(16)$		
	$Y = R + A \rightarrow Y \sim Po(44)$	M1	3.4
	$P(Y = 42) = 0.05866...$ awrt **0.0587**	A1	1.1b
		(2)	
(c)	P(less than 80 passengers checked in) $= 0.183...$	B1	1.1b
	$X \sim B(150, "0.183...")$ mean $= 150 \times "0.183..."$ [= 27.48…]	M1	3.3
	$T \sim Po("27.4...")$ and $1 - P(T \leq 24)$	M1	3.4
	$= 1 - 0.2922\ldots$ awrt **0.708**	A1	2.1
		(4)	
(d)	$H_0: \lambda = 84$ $H_1: \lambda < 84$ (allow 28 for both)	B1	2.5
	$J \sim Po(84)$	M1	1.1b
	Method 1 / Method 2		
	$P(J \leq 67) = 0.03[246...]$ / CR $J \leq 68$	A1	1.1b
	$0.03\ldots < 0.05$ or $67 \leq 68$ or 67 is in the critical region or 67 is significant or Reject H_0. There is evidence at the 5% level of significance that the system is working **slower** than normal.	A1cao	2.2b
		(4)	
			(11 marks)

Notes:

(a)	**B1:**	awrt 0.852
(b)	**M1:**	For combining distributions and sight or use of Po(28 + 16[=44]) Condone 28 + 16 = 42 followed by awrt 0.061
	A1:	awrt 0.0587
(c)	**B1:**	awrt 0.18 may be implied by awrt 27.5 for the mean
	M1:	Setting up a new model B(150, "0.183") and using *np* to calculate the mean.
	M1:	Using the model Po(their *np*) and using or writing $1 - P(T \leq 24)$
	A1:	awrt 0.708
(d)	**B1:**	Both hypotheses correct using λ or μ. Allow 28 instead of 84
	M1:	Writing or using Po(84)
	A1:	awrt 0.03 or $J \leq 68$
	A1cao	dep on previous M mark awarded and a probability found. Drawing a correct inference in context – need the word slower or support for Alex's complaint

Question	Scheme	Marks	AOs
3(a)	$\mathrm{E}(X) = -0.1$ oe	B1	1.1b
		(1)	
(b)	$\mathrm{Var}(X) = \mathrm{E}(X^2) - (\text{"}-0.1\text{"})^2$	M1	1.2
	$\mathrm{E}(X^2) = 8.8$	A1	1.1b
		(2)	
(c)	$(-2)^2 \times 3a + (-1)^2 \times a\left[+0^2 \times b\right] + 1^2 \times a + 2^2 \times c = [\text{"}2\text{"}]$	M1	1.1b
	$7a + 2c = 1$ oe	A1	1.1b
	One of $a + c = 0.25$ **or** $4a + b = 0.75$ **or** $5a + b + c = 1$	M1	3.1a
	Two of $a + c = 0.25$ **or** $4a + b = 0.75$ **or** $5a + b + c = 1$	A1	1.1b
	$a = 0.1$ and $b = 0.35$ and $c = 0.15$	A1	1.1b
		(5)	
(d)	$\mathrm{P}(W > T) = \mathrm{P}(W > 3W - 8) = \mathrm{P}(W < 4)$	M1	3.1a
	$\mathrm{P}(W < 4) = 1 - \left[\mathrm{P}(X = -3) \times \mathrm{P}(Y = 1) + \mathrm{P}(X = -3) \times \mathrm{P}(Y = 2) + \mathrm{P}(X = -2) \times \mathrm{P}(Y = 2)\right]$ **or** $= \mathrm{P}(X \geqslant -1) + \mathrm{P}(X = -2) \times \mathrm{P}(Y \neq 2) + \mathrm{P}(X = -3) \times \mathrm{P}(Y \leqslant 0)$	M1dep	1.1b
	$= 1 - \left[0.3 \times \text{"}0.1\text{"} + 0.3 \times \text{"}0.15\text{"} + 0.15 \times \text{"}0.15\text{"}\right]$ **or** $0.55 + 0.15 \times \left[1 - \text{"}0.15\text{"}\right] + 0.3 \times \left[\text{"}0.3\text{"} + \text{"}0.1\text{"} + \text{"}0.35\text{"}\right]$	M1dep	1.1b
	$= \underline{\mathbf{0.9025}}$	A1	1.1b
		(4)	
			(12 marks)

Notes:

(a)	**B1:**	-0.1 oe
(b)	**M1:**	For recalling and using a correct formula
	A1:	8.8
(c)	**M1:**	For use of $\sum y^2 \mathrm{P}(Y = y)[= 2]$ or $\sum (y^2 + 3)\mathrm{P}(Y = y)[= 5]$ 3 correct products seen
	A1:	For correct equation with *a*'s collected
	M1:	For use of $\sum \mathrm{P}(Y = y) = 1$ or $\mathrm{P}(Y \leqslant 0) = 0.75$ or $1 - \mathrm{P}(Y \leqslant 0) = 0.25$
	A1:	For 2 correct equations
	A1:	*a*, *b* and *c* correct. Award full marks if all 3 correct
(d)	**M1:**	For using the information given to work out the values of *W*. Allow $Y - X$ instead of *W*
	dM1:	For using the information given to work out which are the relevant combinations of *X* and *Y*. The irrelevant ones must not be used.
	M1:	Previous method must be awarded. All required cases identified and their probabilities of *a*, *b* and *c* used. Allow in terms of *a*, *b* and *c*
	A1:	0.9025 (accept awrt 0.903 or exact fraction $\frac{361}{400}$)

Question	Scheme	Marks	AOs
4(a)	$E=\frac{(c+d)(a+c)}{a+b+c+d}$	B1	1.1b
	$O-E=c-"\frac{(c+d)(a+c)}{a+b+c+d}"$	M1	1.1b
	$O-E=\frac{ca+cb+c^2+cd-ac-c^2-ad-dc}{a+b+c+d}$	dM1	1.1b
	$O-E=\frac{cb-ad}{a+b+c+d}$	A1	1.1b
		(4)	
(b)	H_0: There is no association between the age of a person and the main type of investment they have. H_1: There is an association between the age of a person and the main type of investment they have.	B1	3.4
	Degrees of freedom = $(3-1)(2-1)=2$ $\chi^2_{2,0.05}=5.991$	M1	3.1b
	Reject H_0. There is evidence that there is an association between the age of a person and the main type of investment they have.	A1	2.2b
		(3)	
			(7 marks)

Notes:		
(a)	**B1:**	For correct expected value
	M1:	For finding c – their expected value
	dM1:	Dependent on previous method being awarded. For correctly gaining a single fraction
	A1:	Correct answer only
(b)	**B1:**	For correct hypotheses with at least one in context. Allow independent and not independent. Do not accept correlation
	M1:	For using degrees of freedom to set up χ^2 model critical value, implied by CV 5.991 or better
	A1:	Correct conclusion including the words **age** and **investment**. Do not allow contradicting statements. Do not award if hypotheses are the wrong way round or there are no hypotheses.