Mark Scheme (Results)

Summer 2021

Pearson Edexcel International Advanced Level
In Statistics S2 Paper WST02/01

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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 IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

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. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. 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.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

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

Question Number	Scheme	Marks
Throughout the paper the candidates may use different letters to the ones given in the mark scheme.		
1. (a)	[X ~ the number of pansy seeds that do not germinate or Y = the number…that do germinate]	
	$X \sim \mathrm{B}(20, 0.05)$ or $Y \sim \mathrm{B}(20, 0.95)$	B1
(i)	$\mathrm{P}(X \leqslant 4) - \mathrm{P}(X \leqslant 2) = 0.9974 - 0.9245$ or	
	$\binom{20}{3}0.05^3 \times 0.95^{17} + \binom{20}{4}0.05^4 \times 0.95^{16} = 0.05958... + 0.01332...$	M1
	$= 0.072909\ldots$ awrt **0.0729**	A1
(ii)	$\mathrm{P}(X \leqslant 1)$ or $\mathrm{P}(Y \geqslant 19) = 20 \times (0.95)^{19}(0.05) + (0.95)^{20}$	M1
	$= 0.7358$ $= 0.735839\ldots$ awrt **0.736**	A1 (5)
(b)	[Let W = no. of packets where $Y > 18$] $\mathrm{P}(W = 5) = (\text{"0.7358..."})^5$	M1
	$= 0.21573\ldots$ awrt **0.216**	A1 (2)
(c)	$\mathrm{H}_0 : p = 0.05$ $\mathrm{H}_1 : p > 0.05$	B1 (1)
(d)	[V= no. of seeds that do not germinate $V \sim \mathrm{B}(100, 0.05)$ approximates to] $V \sim \mathrm{Po}(5)$	M1A1
	CR for 1-tail in (c): $\mathrm{P}(V \geqslant 9) = 0.0681$, $\mathrm{P}(V \geqslant 10) = 0.0318$, CR $V \geqslant 10$ oe CR for 2-tail in (c): $\mathrm{P}(V \geqslant 10) = 0.0318$, $\mathrm{P}(V \geqslant 11) = 0.0137$, CR $V \geqslant 11$ oe	
	$\mathrm{P}(V \geqslant 8) = 1 - \mathrm{P}(V \leqslant 7)$ $= 1 - 0.8666$ $= 0.1334$	M1 A1
	Accept H_0 or not significant or 8 does not lie in the critical region	dM1
	Data consistent with ***Spany*'s claim** or Insufficient evidence for ***Jem's* belief** or insufficient evidence that **percentage** of **seeds not germinating** is more than **5%** (o.e.)	A1cso (6)
		Total 14

Notes

(a) **B1:** writing or using $\mathrm{B}(20, 0.05)$ [Allow $Y \sim \mathrm{B}(20, 0.95)$ if Y is clearly defined]. Implied by 1 correct prob.

(i) **M1:** for $\mathrm{P}(X \leqslant 4) - \mathrm{P}(X \leqslant 2)$ and one correct prob. or $\mathrm{P}(X = 3) + \mathrm{P}(X = 4)$ and 1 correct prob.

(ii) **M1:** for $\mathrm{P}(X \leqslant 1)$ or $[20] \times (0.95)^{19}(0.05) + (0.95)^{20}$ - condone missing 20

(b) **M1:** for $(\text{their(a)(ii)})^5$

(c) **B1:** both hypotheses correct with p or π

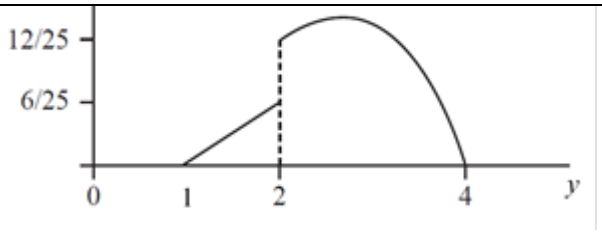
(d) **1st M1:** for realising a Poisson approximation is appropriate. NB Po(95) is M0A0
1st A1: writing or using $V \sim \mathrm{Po}(5)$ i.e correct mean for the Poisson.
2nd M1: for writing or using $1 - \mathrm{P}(V \leqslant 7)$ or $\mathrm{P}(V \leqslant 7) = 0.8666$
or writing $\mathrm{P}(V \geqslant 10) = 0.0318$ or $\mathrm{P}(V \geqslant 9) = 0.0681$ or $\mathrm{P}(V \geqslant 11) = 0.0137$ **leading to a CR**.
Implied by correct CR or probability = awrt 0.133
2nd A1: for awrt 0.133 or $V \geqslant 10$ oe (e.g. $V > 9$) or $V \geqslant 11$ oe allow any letter but CR must match part(c)
3rd dM1: dep on 2nd M1. ft their CR or probability. A correct statement based on comparing 8 with their CR or their prob with 0.05 or 0.025 [condone $0.866 < 0.95$]– contradicting non-contextual comments M0
3rd A1 cso: all previous marks must be awarded. A **correct** statement in context. Need **Bold words.**
NB award M1A1 for a correct contextual statement on its own.
If there are no hypotheses or they are the wrong way around, then 3rd M0 3rd A0

SC1 **Normal approximation:** Award marks in pairs with 2, 4 or 6 marks available
Sight of $\mathrm{N}(5 \text{ or } 95, \sqrt{4.75}^2)$ M1A1; probability awrt 0.125/6 M1A1; Correct contextual concl' dM1A1

SC2 **No approximation:** Use of $\mathrm{B}(100, 0.05)$ M0A0; probability awrt 0.128 or CR $\geqslant 10$ M1A1; then M0A0

Question Number		Scheme	Marks
2.	(a)	[X = number of faults in 4 m^2 so $X \sim$ Po(3)]	
		$P(X=5) = P(X \leqslant 5) - P(X \leqslant 4)$ [= 0.9161 – 0.8153] or $\frac{e^{-3}3^5}{5!}$ (allow λ instead of 3)	M1
		= 0.1008 or 0.100818… awrt **0.101**	A1
			(2)
	(b)	[Y = number of faults in 6 m^2 so] $Y \sim$Po(4.5) and $\left[P(Y>5)\right] = 1 - P(Y \leqslant 5)$ [= 1 – 0.7029]	M1
		= 0.2971 or (calc) 0.29706956… awrt **0.297**	A1
			(2)
	(c)	**0.101** (or ft their answer to (a))	B1ft
		Faults occur **independently/ randomly**	B1
			(2)
	(d)	[F = number of faults in a small rug] $F \sim$ Po(0.9)	B1
		$e^{-"0.9"}n \times 80 + \left(1 - e^{-"0.9"}\right)n \times 60 \geqslant 4000$ or $(\text{awrt } 0.407)n \times 80 + (\text{awrt } 0.593)n \times 60 \geqslant 4000$	M1
		$n \geqslant \frac{4000}{20e^{-"0.9"} + 60} = 58.71\ldots$	M1
		$n =$ **59**	A1
			(4)
	(e)	$H_0 : \lambda = 9$ $H_1 : \lambda > 9$	B1
		$R \sim$ Po("0.9"×10) and [P($R \geqslant 13$)] = 1 – P($R \leqslant 12$) [= 1 – 0.8758]	
		P($R \leqslant 13$) = 0.9261 or P($R \geqslant 14$) = 0.0739 or P($R \leqslant 14$) = 0.9585 or P($R \geqslant 15$) = 0.0415	M1
		[P($R \geqslant 13$)] = 0.1242 awrt 0.124 or CR $R \geqslant 15$ (oe)	A1
		so insufficient evidence to reject H_0 /not significant/ not in critical region	M1
		There is insufficient evidence that the **rate** at which **faults** occur is higher for **Rhiannon**	A1
			(5)
			Total 15

	Notes
(a)	**M1:** for using or writing $P(X \leqslant 5) - P(X \leqslant 4)$ or $\frac{e^{-\lambda}\lambda^5}{5!}$ (Accept letter λ or any value of λ)
(b)	**M1:** writing or using Po(4.5) and sight of $\left[P(Y>5)\right] = 1 - P(Y \leqslant 5)$ Implied by sight of 1 – 0.7029
(c)	**2nd B1:** for a comment about faults occurring **randomly/independently** or Poisson has "**no memory**"
(d)	**B1:** writing or using Po(0.9) May be implied by sight of 0.407 or 0.593 **1st M1:** for $e^{-\lambda}n \times 80 + \left(1 - e^{-\lambda}\right)n \times 60 > 4000$ any value for λ. Allow = 4000 **2nd M1:** for solving their equation leading to a positive value of n. Allow any value of λ and allow n = … **A1:** for an answer of 59 only
(e)	**B1:** both hypotheses correct with λ or μ. Allow 3 or 0.75 or 0.9 instead of 9 **1st M1:** for writing or using Po("9") and writing or using 1 – P($R \leqslant 12$) (implied by 1 – 0.8758) or one of: P($R \leqslant 13$) = 0.9261, P($R \geqslant 14$) = 0.0739, P($R \leqslant 14$) = 0.9585, P($R \geqslant 15$) = 0.0415 **leading to a CR** **1st A1:** for probability = awrt 0.124 or CR of $R \geqslant 15$ oe e.g. $R > 14$ **2nd M1:** for a correct conclusion based on their prob & 0.05 or their CR & 13. Assume correct hypotheses. Do not allow contradicting conclusions **2nd A1:** dep on both Ms for a correct contextual comment including the words in bold.

Question Number	Scheme	Marks
3. (a)		M1 A1 (2)
(b)	$\frac{\mathrm{d}\left(\frac{3}{50}\left(4y^2-y^3\right)\right)}{\mathrm{d}y}=\frac{3}{50}\left(8y-3y^2\right)$	M1
	$\frac{3}{50}\left(8y-3y^2\right)=0$; $\underline{y=\frac{8}{3}}$ oe	M1; A1 (3)
(c)	$\mathrm{E}(Y^2)=\int_1^2\left(\frac{6}{25}y^3-\frac{6}{25}y^2\right)\mathrm{d}y+\int_2^4\left(\frac{12}{50}y^4-\frac{3}{50}y^5\right)\mathrm{d}y$	M1
	$=\left[\frac{6}{100}y^4-\frac{6}{75}y^3\right]_1^2+\left[\frac{12}{250}y^5-\frac{3}{300}y^6\right]_2^4$	A1
	$=\left[\left(\frac{8}{25}\right)-\left(-\frac{1}{50}\right)\right]+\left[\left(\frac{1024}{125}\right)-\left(\frac{112}{125}\right)\right]$; $=\underline{\frac{1909}{250}}$ or **<u>7.636</u>** or **<u>7.64</u>**	dM1; A1 (4)
(d)	$\mathrm{Var}(Y)=\text{"}\frac{1909}{250}\text{"}-2.696^2$	M1
	$=0.367584$ awrt **<u>0.368</u>**	A1 (2)
(e)	$\frac{1}{2}(y-1)\times\frac{6}{25}(y-1)=0.1$ <u>or</u> $\int_1^x\frac{6}{25}(y-1)\,\mathrm{d}y=0.1$	M1
	$\frac{1}{2}(y-1)\times\frac{6}{25}(y-1)=0.1$ <u>or</u> $\frac{6}{25}\left[\left(\frac{x^2}{2}-x\right)+\frac{1}{2}\right]=0.1$ <u>or</u> $\frac{6}{50}(x-1)^2=0.1$	A1
	$(y-1)^2=\frac{5}{6}$ <u>or</u> $y=1\pm\sqrt{\frac{5}{6}}$; $y=1.9128...$ awrt **<u>1.91</u>**	dM1; A1 (4) **Total 15**

	Notes
(a)	**M1:** the two parts must be the right shape and not joined. Ignore labels and condone if it goes below x - axis **A1:** for 6/25, 12/25, 1, 2 and 4 and must not go beyond 4 or < 1 [Can allow "freehand" straight line]
(b)	**1st M1:** for attempting to differentiate $y^n \to y^{n-1}$ for n = 2 <u>or</u> 3 **2nd M1:** for equating their differential ($\neq \mathrm{f}(y)$) to zero and an attempt at solving so must reach y = … **A1:** for $\frac{8}{3}$ oe and allow awrt 2.67 If $y = 0$ is seen it must be rejected.
(c)	**1st M1:** for using $\int y^2\mathrm{f}(y)$ for both parts, <u>and</u> an attempt at integration (some $y^n \to y^{n+1}$) Ignore limits. **1st A1:** for correct integration for both parts. Ignore limits. **2nd dM1 :** dep on 1st M1for adding the 2 parts together <u>and</u> substituting the correct limits in to each part. **2nd A1:** allow 7.64 or 7.636 You will need to check that they have used algebraic integration.
(d)	**M1:** for "their part(c)" – 2.696 ^{2} **A1:** for awrt 0.368
(e)	**1st M1:** allow $\frac{1}{2}t\times\frac{6}{25}(t-1)=0.1$ <u>or</u> $\int_1^x\frac{6}{25}(y-1)\,\mathrm{d}y=0.1$ <u>and</u> some integration and sub' of 1 and x **1st A1:** for a correct equation in any form **2nd dM1:** dependent on 1st M1 for a correct method for solving their equation. Implied by correct answer. **2nd A1:** for awrt 1.91 (second solution should be rejected)

Question Number	Scheme	Marks
4.	[A = the number on the ball] $\mathrm{P}(A=1)=\frac{2}{9}$ $\mathrm{P}(A=2)=\frac{1}{3}$ $\mathrm{P}(A=5)=\frac{4}{9}$	B1
(i)	Possible samples with a range of 4 are: (1,1,5) (1,2,5) (1,5,5)	M1
	(1,1,5) $"\frac{2}{9}" \times "\frac{2}{9}" \times "\frac{4}{9}" \times 3 = \frac{16}{243}$ or (1,5,5) $"\frac{2}{9}" \times "\frac{4}{9}" \times "\frac{4}{9}" \times 3 = \frac{32}{243}$	M1
	(1,2,5) $"\frac{2}{9}" \times "\frac{1}{3}" \times "\frac{4}{9}" \times 6 = \frac{16}{81}$	M1
	$\mathrm{P}(B=4)=\frac{16}{243}+\frac{32}{243}+\frac{16}{81} = \underline{\underline{\frac{32}{81}}}$	A1
(ii)	$\mathrm{P}(B=0)=\left("\frac{2}{9}"\right)^3+\left("\frac{1}{3}"\right)^3+\left("\frac{4}{9}"\right)^3=\frac{11}{81}$	M1
	$\mathrm{P}(B=1)=3\times\frac{2}{9}\times\left(\frac{1}{3}\right)^2+3\times\frac{1}{3}\times\left(\frac{2}{9}\right)^2=\frac{10}{81}$ or $\mathrm{P}(B=3)=3\times\frac{1}{3}\times\left(\frac{4}{9}\right)^2+3\times\frac{4}{9}\times\left(\frac{1}{3}\right)^2=\frac{28}{81}$	M1
	$1-"\frac{11}{81}"-"\frac{10}{81}"-"\frac{32}{81}"=\frac{28}{81}$ or $1-"\frac{11}{81}"-"\frac{28}{81}"-"\frac{32}{81}"=\frac{10}{81}$	M1
	b | 0 | 1 | 3 | 4 $\mathrm{P}(B=b)$ | $\frac{11}{81}$ | $\frac{10}{81}$ | $\frac{28}{81}$ | $\frac{32}{81}$	B1 A1
		(10)
		Total 10

	Notes
(i)	**B1:** for writing or using the 3 correct probabilities
	1st M1: for identifying the 3 possible samples
	2nd M1: for $p\times p\times q\times 3$ or $p\times q\times q\times 3$ where p and q are probabilities with $(p+q)<1$
	3rd M1: for $p\times q\times r\times 6$ where p, q and r are probabilities with $(p+q+r)=1$
	A1: for $\frac{32}{81}$ or awrt 0.395 [Calc: 0.3950617…]
(ii)	**1st M1:** for $p^3+q^3+r^3$ (for their p, q and r)
	2nd M1: for $3\times p\times(q)^2+3\times q\times(p)^2$ or $3\times q\times(r)^2+3\times r\times(q)^2$ (for their p, q and r)
	3rd M1: for use of all probabilities of P(B = b) adding to 1 [Must have 3, 4 or 5 values for b]
	B1: for ranges 0, 1, 3 and 4 with none omitted and no extras. Allow extras if assigned probability of 0
	A1: for a fully correct probability distribution.
SC A0 in (i)	If A0 scored in (i) and all other marks scored in (ii) and correct prob's for 2 values of b : award A1 in (ii)

Question Number	Scheme	Marks
5 (a)(i)	If $y = 0$ then $1-(\alpha+\beta y^2)=0 \quad \therefore \ \alpha = 1$ *	B1cso
(ii)	If $y = 5$ then $1-(\alpha+\beta y^2)=1$	
	$1+25\beta=0 \quad \therefore \beta=-\frac{1}{25}$ *	B1cso
		(2)
(b)	$F(y)=\frac{1}{25}y^2$ so $f(y)=\frac{dF(y)}{dy}=\frac{2}{25}y$	M1
	$\therefore [f(y)=]\begin{cases}\frac{2}{25}y & 0\leqslant y\leqslant 5\\ 0 & \text{otherwise}\end{cases}$	A1
		(2)
(c)	$\left[P\left(R>\frac{11}{5}\right)=P\left(Y>\frac{5}{3}\right)=1-\frac{1}{25}\times\left(\frac{5}{3}\right)^2=\right]\ \underline{\underline{\frac{8}{9}}}$ oe	B1
	$\frac{3d-\frac{11}{5}}{3d-d}=\frac{8}{9}$ oe or $\frac{\frac{11}{5}-d}{3d-d}=\frac{1}{9}$ oe	M1
	$d=\underline{\underline{\frac{9}{5}}}$ oe	A1
		(3)
(d)	$P\left(Y<\frac{11}{5}\right)=\frac{121}{625}$ or 0.1936	B1
	[Let G = the number of spins with distance < 2.2 m]	
	$[P(G\geqslant 5)=]$	
	$\left(\frac{"1"}{9}\right)^3\times\left(\frac{"121"}{625}\right)^3+3\times\left(\frac{"1"}{9}\right)^2\times\left(\frac{"8"}{9}\right)\times\left(\frac{"121"}{625}\right)^3+3\times\left(\frac{"1"}{9}\right)^3\times\left(\frac{"121"}{625}\right)^2\times\left(\frac{"504"}{625}\right)$	M1, M1
	= 0.000 373226 awrt **0.000 373**	A1
		(4)
		Total 11

Notes

(a) (i) **B1:** for stating or using the fact that when $y = 0$ then $\alpha+\beta y^2 = 1$

(ii) **B1:** for stating or using that when $y = 5$ then $\alpha+\beta y^2 = 0$ and setting up the equation leading to $\beta=-\frac{1}{25}$

(b) **M1:** for differentiating. Implied by $\pm\frac{2}{"25"}y$ can ft their value of β

A1: for a fully correct f(y) defined for the whole range.

(c) **B1:** for using F(y) and $\frac{5}{3}$ to find P($Y > \frac{5}{3}$). Allow $\frac{8}{9}$ or any exact equivalent.

M1: for LHS = p where $0 < p < 1$

A1: for $\frac{9}{5}$ or any exact equivalent e.g. 1.8

(d) **B1:** for $\frac{121}{625}$ or awrt 0.194 This mark could be implied by a correct answer.

1st M1: for $p^3q^3+np^2(1-p)q^3+np^3q^2(1-q)$ where p and q are probabilities and n is an integer > 0

2nd M1: for $p^3q^3+3p^2(1-p)q^3+3p^3q^2(1-q)$ where p and q are probabilities.

A1: for awrt 0.000 373

Question Number	Scheme	Marks
6. (i)	$z = 1.25$	B1
	$\frac{187.5-\mu}{\sigma}=1.25$	M1 M1 A1
	$187.5-\mu=1.25\sigma$	
	$\mu = 225p$	M1
	$\sigma=\sqrt{225p(1-p)}$	M1
	$(187.5-225p)^2=(1.25)^2\times225p(1-p)$ or $(150-180p)^2=225p(1-p)$ (o.e.)	M1
	e.g. $900(5-6p)^2=225(p-p^2) \Rightarrow 4(25-60p+36p^2)=p-p^2$	A1*
	Leading to $145p^2-241p+100=0$ *	
(ii)	$[(29p-25)(5p-4)=0\Rightarrow]$ $p=0.8$ or $p=\frac{25}{29}$ (accept: 0.862(0689…))	M1
	[p =] 0.8 because 0.862 gives a mean greater than 188 (oe)	A1
		(10)
		Total 10

	Notes
(i)	**B1:** for 1.25 or better (calculator gives: 1.25027…)
	1st M1: for attempting to use a continuity correction i.e. for sight of 188 ± 0.5
	2nd M1: for standardising using μ and σ or np and $\sqrt{np(1-p)}$ (Condone letter n or any integer > 0)
	1st A1: for a correct equation with compatible signs, allow 1.250... If using a value for n it must be 225
	3rd M1: for $\mu = 225p$ seen at any stage in the working.
	4th M1: for $\sigma=\sqrt{225p(1-p)}$ seen at any stage in the working. Must be for σ not $\sigma^2 = 225p(1-p)$
	5th M1: for squaring to get a quadratic equation in p
	2nd A1*: dep on all previous Ms and use of 1.25 (with correct sign) for at least 1correct intermediate step from a correct quadratic equation e.g one of those in scheme for 5th M1
(ii)	**M1:** for solving the quadratic correctly–leading to p = … or implied by 0.8 or awrt 0.862
	A1: for 0.8 and a correct reason to eliminate 0.862