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INTERNATIONAL A LEVEL MATHEMATICS • STATISTICS 2 (WST02)

Statistics 2 Practice Paper 2

Mark Scheme

AIMING FOR A

Written in the style of the Pearson Edexcel International Advanced Level paper (WST02/01) • 75 marks

Every question marked line by line the way an examiner marks it, with notes on the common errors

Mark every line, not just the answer. Method marks are given for a correct method even when the final answer is wrong. If you lost marks, find the *first* line where your working differs from the scheme. That is the thing to fix.

Code	Meaning
M1	Method mark: for knowing a correct method and attempting to apply it. Small slips in the working do not lose this mark.
dM1	Dependent method mark: can only be given if the method mark before it has been given.
A1	Accuracy mark: for a correct answer or line of working. It depends on the method mark before it.
B1	Independent mark: for a correct result or statement, whatever method was used.
*	The answer is given in the question. Every step must be shown, and the answer must follow from correct working (cso).
cao / cso	Correct answer only / correct solution only, with no errors anywhere in the working.
ft / oe	Follow through from your own earlier answer / or any correct equivalent form.
awrt	Answers which round to the value given, so $-0.9637\ldots$ earns "awrt -0.964".

Tables, tests and context. Write the distribution with its parameters, such as $X \sim \mathrm{B}(20, 0.3)$, and a probability statement before every table value: values from the binomial and Poisson tables are given to 4 decimal places. Hypotheses must use p or λ, and a test needs a conclusion in the context of the question. For a normal approximation, show the continuity correction and the standardisation.

Rough grade guide (out of 75): A* **61** • A **54** • B **45** • C **37**

Based on recent WST02 grade boundaries. Real boundaries change every series, so treat this as a guide, not a grade.

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What to revise next

Write in your score for each question. Where you dropped marks, tap the chapter to practise ten more exam questions on it.

Q	What it tested	Marks	Practise it	Score
1	Finding p from a probability; a Poisson approximation	9	Ch 1 Binomial Distributions Ch 3 Approximations	
2	A two-tailed Poisson test: critical region and significance level	10	Ch 7 Hypothesis Testing Ch 2 Poisson Distributions	
3	The sampling distribution of a range; a binomial over samples	10	Ch 6 Sampling Ch 1 Binomial Distributions	
4	A uniform distribution from its mean and variance; a binomial count	11	Ch 5 Continuous Uniform Ch 1 Binomial Distributions	
5	A normal approximation to a Poisson, used in a test	11	Ch 3 Approximations Ch 7 Hypothesis Testing	
6	A piecewise pdf: k, the cdf, a quartile; repeated observations	12	Ch 4 Continuous Random Variables Ch 1 Binomial Distributions	
7	A two-tailed binomial test and the least sample size	12	Ch 7 Hypothesis Testing Ch 1 Binomial Distributions	
	Total	**75**		

Where did the marks go? If you lost the first marks of a question, the method needs work: go back to that chapter's key skills page. If you lost the final marks, the method is fine and the gap is a link between two chapters: a probability from one distribution used as p in another, a rate rescaled before a test, or a quartile found in the wrong piece of a pdf. Paper 3 gives no route at all and hides a trap in every question.

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Question 1

9 marks

Part	Scheme	Marks
(a)	$(1-p)^2 = 0.9025$ $1-p = 0.95$, so $\boxed{p = 0.05}$ (rejecting $1-p = -0.95$)	**M1** **A1** **(2)**
(b)	$X \sim \text{B}(10, 0.05)$ $\text{P}(X \geqslant 2) = 1 - \text{P}(X \leqslant 1) = 1 - 0.9139$ $\boxed{0.0861}$	**B1** **M1** **A1** **(3)**
(c)	$Y \sim \text{B}(120, 0.05)$ approximated by Po(6) $\text{P}(Y > 8) = 1 - \text{P}(Y \leqslant 8) = 1 - 0.8472$ $\boxed{0.1528}$	**B1** **M1** **A1** **(3)**
(d)	$n = 120$ is large and $p = 0.05$ is small	**B1** **(1)**
		Total for Question 1: 9 marks

Question 2

10 marks

Part	Scheme	Marks
(a)	Accidents occur independently (singly), at random Accidents occur at a constant average rate	**B1** **B1** **(2)**
(b)	$\text{H}_0 : \lambda = 8$, $\text{H}_1 : \lambda \neq 8$ (or $\lambda = 4$, $\lambda \neq 4$ per month)	**B1** **(1)**
(c)	$X \sim \text{Po}(8)$ for two months Lower tail: $\text{P}(X \leqslant 3) = 0.0424$ and $\text{P}(X \leqslant 4) = 0.0996$, so $X \leqslant 3$ Upper tail: $\text{P}(X \geqslant 14) = 1 - 0.9658 = 0.0342$ and $\text{P}(X \geqslant 13) = 0.0638$ $\boxed{X \leqslant 3 \text{ or } X \geqslant 14}$ *Using* Po(4)*, the rate for one month, scores 0 in (c).*	**M1** **A1** **M1** **A1** **(4)**
(d)	$0.0424 + 0.0342 = \boxed{0.0766}$	**B1** **(1)**
(e)	3 lies in the critical region, so reject H_0 There is evidence that the mean rate of accidents has changed (it has decreased)	**M1** **A1** **(2)**
		Total for Question 2: 10 marks

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Question 3

10 marks

Part	Scheme	Marks
(a)	Possible ranges 0, 1, 3 and 4	B1
	$P(R = 0) = 0.4^3 + 0.4^3 + 0.2^3$	M1
	$P(R = 0) = 0.136$	A1
	$P(R = 1)$: only 1s and 2s, not all the same: $0.8^3 - 0.4^3 - 0.4^3$, or $3 \times 0.4^2 \times 0.4 \times 2$	M1
	$P(R = 1) = 0.384$, $P(R = 3) = 0.6^3 - 0.4^3 - 0.2^3 = 0.144$	A1
	$P(R = 4) = 1 - 0.136 - 0.384 - 0.144 = 0.336$	A1
		(6)
(b)	$0 \times 0.136 + 1 \times 0.384 + 3 \times 0.144 + 4 \times 0.336$	M1
	$\boxed{2.16}$	A1
		(2)
(c)	B$(8, 0.136)$: $\binom{8}{2}(0.136)^2(0.864)^6$	M1
	$\boxed{0.215}$	A1
		(2)
	Total for Question 3: 10 marks	

Question 4

11 marks

Part	Scheme	Marks
(a)	$\frac{a+b}{2} = 7$	B1
	$\frac{(b-a)^2}{12} = 12$	B1
	$b - a = 12$ and $a + b = 14$	M1
	$\boxed{a = 1,\ b = 13}$	A1
		(4)
(b)	$E(X^2) = \text{Var}(X) + \left(E(X)\right)^2$	M1
	$= 12 + 49 = 61$	A1
	$E(X^2) - E(X) = 61 - 7 = \boxed{54}$	A1
	Subtracting $\left(E(X)\right)^2$, or not squaring it, scores M0.	
		(3)
(c)	$\frac{13 - 10}{12} = \boxed{0.25}$	B1
		(1)
(d)	$Y \sim$ B$(20, 0.25)$	M1
	$P(Y \geqslant 8) = 1 - P(Y \leqslant 7) = 1 - 0.8982$	M1
	$\boxed{0.1018}$	A1
		(3)
	Total for Question 4: 11 marks	

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Question 5

11 marks

Part	Scheme	Marks
(a)	$X \sim$ Po(30) approximated by N(30, 30)	**B1**
	$P(X > 36) = P(X \geqslant 37) \approx P(Y > 36.5)$	**M1**
	$z = \dfrac{36.5 - 30}{\sqrt{30}} = 1.19$, so $1 - 0.8830$	**M1**
	$\boxed{0.1170}$	**A1**
		(4)
(b)	$\lambda = 30$ is large	**B1**
		(1)
(c)	$H_0 : \lambda = 30$, $H_1 : \lambda > 30$	**B1**
	$P(X \geqslant 40) \approx P(Y > 39.5)$	**M1**
	$z = \dfrac{39.5 - 30}{\sqrt{30}} = 1.73$	**M1**
	$1 - 0.9582 = 0.0418$ (or $z = 1.73 > 1.6449$)	**A1**
	$0.0418 < 0.05$, so reject H_0	**M1**
	There is evidence to support the manager's belief that the mean rate of sales has increased	**A1**
	The continuity correction is 39.5, not 40.5: $X \geqslant 40$ starts at 39.5. Using 40.5 gives $z = 1.92$ and loses the first M1.	
		(6)
		Total for Question 5: 11 marks

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Question 6

12 marks

Part	Scheme	Marks
(a)	Area of the triangle: $\frac{1}{2} \times 6 \times 2k = 1$	M1
	$\boxed{k = \frac{1}{6}}$	A1
		(2)
(b)	$0 \leqslant x \leqslant 2$: $\int_0^x \frac{t}{6}\,\mathrm{d}t = \frac{x^2}{12}$	M1
	$2 < x \leqslant 6$: $\mathrm{F}(x) = \frac{1}{3} + \int_2^x \frac{6-t}{12}\,\mathrm{d}t$	M1
	$= \frac{12x - x^2 - 12}{24}$	A1
	$\mathrm{F}(x) = 0$ for $x < 0$, $\mathrm{F}(x) = 1$ for $x > 6$, and all four parts with correct inequalities	A1
	The second piece must start from $\mathrm{F}(2) = \frac{1}{3}$. *Check:* $\mathrm{F}(6) = 1$	
		(4)
(c)	$\mathrm{F}(2) = \frac{1}{3} > 0.25$, so the quartile is in the first piece: $\frac{x^2}{12} = 0.25$	M1
	$\boxed{\sqrt{3} = 1.73}$	A1
		(2)
(d)	$1 - \mathrm{F}(4) = 1 - \frac{48 - 16 - 12}{24}$	M1
	$\boxed{\frac{1}{6}}$	A1
		(2)
(e)	$\mathrm{B}\left(5, \frac{1}{6}\right)$: $10\left(\frac{1}{6}\right)^2\left(\frac{5}{6}\right)^3$	M1
	$\boxed{0.161}$	A1
		(2)
	Total for Question 6: 12 marks	

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Question 7

12 marks

Part	Scheme	Marks
(a)	$H_0 : p = 0.25,\ H_1 : p \neq 0.25$	**B1** **(1)**
(b)	$X \sim B(30, 0.25)$ Lower: $P(X \leqslant 2) = 0.0106$ and $P(X \leqslant 3) = 0.0374$, so $X \leqslant 2$ Upper: $P(X \geqslant 13) = 1 - 0.9784 = 0.0216$ and $P(X \geqslant 12) = 1 - 0.9493 = 0.0507$ $\boxed{X \leqslant 2 \text{ or } X \geqslant 13}$	**M1** **A1** **M1** **A1** **(4)**
(c)	$0.0106 + 0.0216 = \boxed{0.0322}$	**B1** **(1)**
(d)	12 is not in the critical region (do not reject H_0) There is insufficient evidence to support Asha's belief that the probability is not 0.25 *Using* $1 - P(X \leqslant 12)$ *for* $P(X \geqslant 12)$ *wrongly puts 12 in the critical region.*	**M1** **A1** **(2)**
(e)	$P(\text{no reds}) = 0.75^n$ Two-tailed, so the lower tail must be at most 0.025: $0.75^n \leqslant 0.025$ $n \geqslant \dfrac{\ln 0.025}{\ln 0.75} = 12.8$ (or $0.75^{12} = 0.0317$ and $0.75^{13} = 0.0238$) $\boxed{n = 13}$ *Comparing with 0.05 gives* $n = 11$*: M0. The inequality sign reverses when dividing by* $\ln 0.75 < 0$.	**B1** **M1** **M1** **A1** **(4)**
		Total for Question 7: 12 marks

TOTAL FOR PAPER: 75 MARKS