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INTERNATIONAL A LEVEL MATHEMATICS • STATISTICS 2 (WST02)

Statistics 2 Practice Paper 3

Mark Scheme

AIMING FOR A/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* **56** • A **49** • B **40** • C **32**

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	A least sample size; choosing between approximations	12	Ch 1 Binomial Distributions Ch 3 Approximations	
2	Poisson tests where the nearest tail is over 5%	12	Ch 7 Hypothesis Testing Ch 2 Poisson Distributions	
3	A two-piece pdf: quartile at the join, median and skewness	13	Ch 4 Continuous Random Variables	
4	A stick broken at random: two regions, $\mathrm{E}(X^2)$	13	Ch 5 Continuous Uniform Ch 1 Binomial Distributions	
5	A critical region by normal approximation	12	Ch 3 Approximations Ch 7 Hypothesis Testing	
6	The sampling distribution of a median	13	Ch 6 Sampling	
	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 the trap: an inequality reversed by a negative logarithm, a tail just over 5%, a quartile at the join of a pdf, a region at the other end of a stick, or a continuity correction the wrong way. At grade A* the method is rarely the problem; checking every answer against the situation is.

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Question 1

12 marks

Part	Scheme	Marks
(a)	P(at least one) = $1 - 0.92^n > 0.95$	**M1**
	$0.92^n < 0.05$	**A1**
	$n > \dfrac{\ln 0.05}{\ln 0.92} = 35.9$, reversing the inequality as $\ln 0.92 < 0$ (or $0.92^{35} = 0.0540$, $0.92^{36} = 0.0497$)	**M1**
	$\boxed{36}$	**A1**
	$n < 35.9$, or rounding down to 35, loses the last two marks.	**(4)**
(b)	$np = 20$ is large and p is not small (so a Poisson approximation is not suitable)	**B1**
	N(20, 18.4), from $250 \times 0.08 \times 0.92$	**M1**
	$P(X < 15) = P(X \leqslant 14) \approx P(Y < 14.5)$	**M1**
	$z = \dfrac{14.5 - 20}{\sqrt{18.4}} = -1.28$	**M1**
	$1 - 0.8997 = \boxed{0.1003}$	**A1**
		(5)
(c)	$p = 0.02$ is small: Po(5)	**B1**
	$1 - P(W \leqslant 8) = 1 - 0.9319$	**M1**
	$\boxed{0.0681}$	**A1**
		(3)
		Total for Question 1: 12 marks

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Question 2

12 marks

Part	Scheme	Marks
(a)	$H_0 : \lambda = 2$, $H_1 : \lambda > 2$ (or $\lambda = 0.4$, $\lambda > 0.4$ per page)	**B1** **(1)**
(b)	$X \sim$ Po(2) for 5 pages $P(X \geqslant 5) = 1 - 0.9473 = 0.0527 > 0.05$ and $P(X \geqslant 6) = 1 - 0.9834 = 0.0166$ $\boxed{X \geqslant 6}$ *The trap: 0.0527 is nearer to 5%, but it is more than 5%, so $X = 5$ is not in the critical region.*	**M1** **M1** **A1** **(3)**
(c)	$\boxed{0.0166}$	**B1** **(1)**
(d)	5 is not in the critical region, so do not reject H_0 There is insufficient evidence to support the manager's suspicion that the mean rate of errors has increased	**M1** **A1** **(2)**
(e)	$H_0 : \lambda = 10$, $H_1 : \lambda < 10$ (25 pages) $Y \sim$ Po(10): $P(Y \leqslant 4)$ $= 0.0293$ $0.0293 < 0.05$, so reject H_0 There is evidence to support the second typist's claim that her mean rate of errors is less than 0.4 per page	**B1** **M1** **A1** **M1** **A1** **(5)**
		Total for Question 2: 12 marks

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Question 3

13 marks

Part	Scheme	Marks
(a)	$\int_0^2 kx^2\,\mathrm{d}x + \int_2^6 k(6-x)\,\mathrm{d}x = 1$ (the second is a triangle of area $8k$)	M1
	$\frac{8k}{3} + 8k = 1$	A1
	$k = \frac{3}{32}$	A1
		(3)
(b)	$\mathrm{F}(2) = \frac{3}{32} \times \frac{8}{3} = \frac{1}{4}$	M1
	lower quartile = 2	A1
		(2)
(c)	$\mathrm{F}(x) = \frac{1}{4} + \int_2^x \frac{3}{32}(6-t)\,\mathrm{d}t$	M1
	$= \frac{1}{4} + \frac{3}{32}\left(6x - \frac{x^2}{2} - 10\right)$	A1
	$\mathrm{F}(x) = \frac{36x - 3x^2 - 44}{64}$	A1
		(3)
(d)	$\mathrm{F}(2) = \frac{1}{4} < \frac{1}{2}$, so the median is in the second piece: $\frac{36m - 3m^2 - 44}{64} = \frac{1}{2}$	M1
	$3m^2 - 36m + 76 = 0$, so $m = 6 \pm \sqrt{\frac{32}{3}}$	A1
	2.73, rejecting 9.27 as it is outside $2 < x \leqslant 6$	A1
		(3)
(e)	Mode = 2 (the peak, where the two pieces meet), and median = 2.73	M1
	Mode $<$ median, so positive skew	A1
		(2)
	Total for Question 3: 13 marks	

Question 4

13 marks

Part	Scheme	Marks
(a)	Shorter piece s, longer $60-s$: $s < \frac{1}{3}(60-s)$, so $s < 15$	M1
	$X < 15$ **or** $X > 45$ (the break can be near either end)	M1
	$\frac{30}{60} = \boxed{0.5}$	A1
	Considering only $X < 15$ gives 0.25: M1 M0 A0.	(3)
(b)	Shorter less than 6: $X < 6$ or $X > 54$, probability $\frac{12}{60}$	M1
	$\frac{12/60}{30/60}$	M1
	$\boxed{0.4}$	A1
		(3)
(c)	Side $\frac{X}{4}$: $\frac{X^2}{16} > 100$, so $X > 40$	M1
	$\frac{20}{60} = \boxed{\frac{1}{3}}$	A1
		(2)
(d)	$\mathrm{E}\left(\frac{X^2}{16}\right) = \frac{1}{16}\left(\mathrm{Var}(X) + \left(\mathrm{E}(X)\right)^2\right)$	M1
	$\mathrm{Var}(X) = \frac{60^2}{12} = 300$, $\mathrm{E}(X) = 30$	A1
	$\frac{300+900}{16} = \boxed{75\,\mathrm{cm}^2}$	A1
	$\frac{30^2}{16} = 56.25$ *uses* $\left(\mathrm{E}(X)\right)^2$ *for* $\mathrm{E}(X^2)$*: M0.*	(3)
(e)	B$(10, 0.5)$: $1 - \mathrm{P}(Y \leqslant 5) = 1 - 0.6230$	M1
	$\boxed{0.3770}$	A1
		(2)
	Total for Question 4: 13 marks	

Question 5

12 marks

Part	Scheme	Marks
(a)	$H_0 : p = 0.35,\ H_1 : p < 0.35$	**B1** **(1)**
(b)	$n = 200$ is large and $p = 0.35$ is close to 0.5 (both np and $n(1-p)$ are large)	**B1** **(1)**
(c)	N(70, 45.5) $P(X \leqslant c) \approx P(Y < c + 0.5) < 0.05$ $\frac{c + 0.5 - 70}{\sqrt{45.5}} < -1.6449$ $c < 58.4$ $\boxed{X \leqslant 58}$ *Using $c - 0.5$ gives $c < 59.4$ and $X \leqslant 59$: M0 for the continuity correction.*	**B1** **M1** **M1** **A1** **A1** **(5)**
(d)	$P(Y < 58.5)$ $z = \frac{58.5 - 70}{\sqrt{45.5}} = -1.70$ $1 - 0.9554 = \boxed{0.0446}$	**M1** **M1** **A1** **(3)**
(e)	59 is not in the critical region (or $P(X \leqslant 59) \approx P(Z < -1.56) = 0.0594 > 0.05$) Do not reject H_0: insufficient evidence that the proportion using the app has fallen	**M1** **A1** **(2)**
		Total for Question 5: 12 marks

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Question 6

13 marks

Part	Scheme	Marks
(a)	M is calculated from the sample alone and contains no unknown parameters	**B1** **(1)**
(b)	Possible values of M: 10, 20 and 50 $M = 10$ when at least two coins are 10c: $0.6^3 + 3 \times 0.6^2 \times 0.4$ $P(M = 10) = 0.648$ $M = 50$ when at least two are 50c: $0.1^3 + 3 \times 0.1^2 \times 0.9$ $P(M = 50) = 0.028$ $P(M = 20) = 1 - 0.648 - 0.028$, or directly with $(10, 20, 50)$ in 6 orders $P(M = 20) = 0.324$ *Each arrangement must be counted:* $(10, 10, 20)$ *occurs in 3 orders and* $(10, 20, 50)$ *in 6. Missing the factor 3 or 6 loses the A marks that depend on it.*	**B1** **M1** **A1** **M1** **A1** **M1** **A1** **(7)**
(c)	$10 \times 0.648 + 20 \times 0.324 + 50 \times 0.028$ $\boxed{14.36}$	**M1** **A1** **(2)**
(d)	Median = mean only when the three values are equal (the values are not equally spaced) $0.6^3 + 0.3^3 + 0.1^3$ $\boxed{0.244}$	**M1** **M1** **A1** **(3)**
		Total for Question 6: 13 marks

TOTAL FOR PAPER: 75 MARKS