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EDEXCEL A LEVEL FURTHER MATHEMATICS: QUESTIONS BY TOPIC

Poisson and Binomial Distributions (2)

Further Statistics 1 · Topic 2

7 questions · 84 marks · Mark schemes included

Pearson Edexcel A Level Further Mathematics (9FM0), June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
2.1 THE POISSON DISTRIBUTION		5 Qs · 61 marks	3
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2.2 MEAN AND VARIANCE OF BINOMIAL AND POISSON		2 Qs · 23 marks	22
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QUESTIONS

7 questions · 84 marks · 2 sub-topics



SUB-TOPIC 2.1

THE POISSON DISTRIBUTION

Sub-topic 2.1 · 5 questions · 61 marks · lowest tariff first



(Total for Question 2 is 7 marks)



- Information was collected about accidents on the *Seapron* bypass. It was found that the number of accidents per month could be modelled by a Poisson distribution with mean 2.5

Following some work on the bypass, the numbers of accidents during a series of 3-month periods were recorded. The data were used to test whether or not there was a change in the mean number of accidents per month.

- (a) Stating your hypotheses clearly and using a 5% level of significance, find the critical region for this test. You should state the probability in each tail. (5)
- (b) State $P(\text{Type I error})$ using this test.

Data from the series of 3-month periods are recorded for 2 years.

- (c) Find the probability that at least 2 of these 3-month periods give a significant result. (3)

Given that the number of accidents per month on the bypass, after the work is completed, is actually 2.1 per month,

- (d) find $P(\text{Type II error})$ for the test in part (a)







(Total for Question 5 is 12 marks)



4. Liam and Simone are studying the distribution of oak trees in some woodland. They divided the woodland into 80 equal squares and recorded the number of oak trees in each square. The results are summarised in Table 1 below.

Number of oak trees in a square	0	1	2	3	4	5	6	7 or more
Frequency	1	4	21	23	13	11	7	0

Table 1

Liam believes that the oak trees were deliberately planted, with 6 oak trees per square and that a constant proportion p of the oak trees survived.

- (a) Suggest the model Liam should use to describe the number of oak trees per square. (2)

Liam decides to test whether or not his model is suitable and calculates the expected frequencies given in Table 2.

Number of oak trees in a square	0 or 1	2	3	4	5	6
Expected frequency	5.53	14.89	24.26	22.24	10.87	2.21

Table 2

- (b) Showing your working clearly, complete the test using a 5% level of significance. You should state your critical value and conclusion clearly. (7)

Simone believes that a Poisson distribution could be used to model the number of oak trees per square. She calculates the expected frequencies given in Table 3.

Number of oak trees in a square	0 or 1	2	3	4	5	6 or more
Expected frequency	12.69	16.07	s	14.58	t	9.37

Table 3

- (c) Find the value of s and the value of t , giving your answers to 2 decimal places. (4)
- (d) Write down hypotheses to test the suitability of Simone's model. (1)
- The test statistic for this test is 8.749
- (e) Complete the test. Use a 5% level of significance and state your critical value and conclusion clearly. (3)
- (f) Using the results of these tests, explain whether the origin of this woodland is likely to be cultivated or wild. (2)







(Total for Question 4 is 19 marks)

Question 5 continued



Question 5 continued

(Total for Question 5 is 10 marks)



SUB-TOPIC 2.2

MEAN AND VARIANCE OF BINOMIAL AND POISSON

Sub-topic 2.2 · 2 questions · 23 marks · lowest tariff first







Question 4 continued

(Total for Question 4 is 10 marks)



Question 5 continued

Question 5 continued



Question 5 continued

(Total for Question 5 is 13 marks)



MARK SCHEMES

official mark schemes



Qu	Scheme	Mark	AO
(a)	1 st M1 for an attempt at $E(X)$, at least the final 2 products seen <u>or</u> an answer of 2 2 nd M1 for attempting a correct expression for $E(X^2)$, at least 3 non-zero products seen A1 for 4.9 or exact equivalent		
(b)	1 st M1 for attempting a correct expression, at least 3 non-zero products seen (implied by 176.9) 2 nd M1 for a correct method, ft their 176.9 and their 8.9 but must be intending $E(X^4)$ and $E(X^2)$ A1 for 97.69 or awrt 97.7		

Qu	Scheme	Mark	AO
2 (a)	(i) 0.20901... awrt 0.209	B1	3.4
	(ii) 0.30844.. awrt 0.308	B1 (2)	1.1b
(b)	$H_0: \lambda = 2.4$ (or $\mu = 6$) $H_1: \lambda \neq 2.4$ (or $\mu \neq 6$)	B1	2.5
	$[E = \text{no. of errors}] E \sim \text{Po}(6)$	M1	3.3
	$P(E \leq 1) = 0.0174$ <u>or</u> $P(E \leq 2) = 0.0620$ and $P(E \leq 11) = 0.980$ <u>or</u> $P(E \geq 12) = 0.0201$	M1	3.4
	Critical region: $E \leq 1$ or $E \geq 12$	A1 (4)	1.1b
(c)	$[P(\text{Type I error}) = 0.0174 + 0.0201 =]$ 0.0375 (Calc gives: $0.017351... + 0.0200919... = 0.037443...$)	B1ft (1)	1.2
		(7 marks)	

Notes			
(a)	1 st B1 for awrt 0.209	2 nd B1 for awrt 0.308	
(b)	B1 for both hypotheses correct in terms of λ or μ (allow $\lambda = 6$ etc) 1 st M1 for selecting the correct model. Sight or use of $\text{Po}(6)$ 2 nd M1 for use of the correct model with two probs correct to 2.s.f. (accept $P(E \geq 12) = 0.02$) Must see attempt at lower and upper limit. Probabilities may be seen in (c). A1 for correct critical region (both parts). Allow $E \leq 1$ and $E \geq 12$ or $E \leq 1, E \geq 12$ etc Writing CR as probability statements is A0 NB: Completely correct CR implies M1M1A1 <u>SC: 1-tailed test</u> B0 as hypotheses are incorrect M1 for sight or use of $\text{Po}(6)$ M1 (dep on H_1) for sight of $P(E \leq 1) = 0.0174$ or $P(E \geq 11) = 0.0426$, in line with their H_1 A1 for CR: $E \leq 1$ or CR: $E \geq 11$, in line with their hypotheses		
(c)	B1ft for 0.0375 or 0.0374 <u>or</u> summing their two appropriate probs (ft their CR) NB: If candidate uses a 1-tailed test, this mark cannot be gained		



Qu	Scheme	Marks	AO	
5(a)	$H_0 : \lambda = 2.5$ (or $\mu = 7.5$) $H_1 : \lambda \neq 2.5$ (or $\mu \neq 7.5$)	B1	2.5	
	[X = no. of accidents in a 3-month period] $X \sim \text{Po}(7.5)$	M1	3.3	
	$P(X \leq 2) = 0.0203$ (calc: 0.020256...) { or $P(X \leq 3) = 0.0591$ }			
	$P(X \leq 13) = 0.9784$ so $P(X \geq 14) = 0.0216$ (calc: 0.0215646...)	M1	3.4	
	{or $P(X \geq 15) = 0.0103$ }			
	Giving Critical region of: $X \leq 2$	A1	1.1b	
	$X \geq 14$	A1	1.1b	
		(5)		
	(b)	$[0.0203 + 0.0216] = \text{awrt } \underline{0.0419}$ <u>or</u> (calc: 0.041821366... awrt <u>0.0418</u>)	B1ft	1.2
		(1)		
(c)	[Let M = no of 3-month periods with a significant result]			
	$M \sim B(8, "0.0419")$	M1	3.3	
	$[P(M \geq 2)] = 1 - P(M \leq 1)$	M1	1.1b	
	$[= 1 - 0.9584...]$			
	$= 0.04153...$ (calc: 0.041394...) [<u>0.04139~0.04154</u>]	A1cso	1.1b	
		(3)		
(d)	$Y \sim \text{Po}(6.3)$	M1	3.3	
	$P(\text{Type II error}) = P(3 \leq Y \leq 13)$ or $P(Y \leq 13) - P(Y \leq 2)$	M1	3.4	
	$[= 0.9945147... - 0.049846...]$			
	$= 0.9446...$ awrt <u>0.945</u>	A1	1.1b	
		(3)		
		(12 marks)		
	Notes			
(a)	B1 for both hypotheses in terms of λ or μ (either way around)			
	1 st M1 for selecting the correct Po model. Sight or use of Po(7.5) may be implied by 2 nd M1			
	2 nd M1 for using the correct model to find one of these probs with correct label (2sf or better)			
	1 st A1 for one end correct	Allow any letter, even $CR \leq 2$ or set notation but not $P(X \leq 2)$ Can have $X < 3$ and $X > 13$ etc		
	2 nd A1 for a fully correct CR			
	(b)	B1ft for awrt 0.0419 <u>or</u> awrt 0.0418		
		<u>or</u> ft addition of their two probs provided both are $0 < \text{prob} < 0.025$ (awrt 3sf)		
	(c)	1 st M1 for selecting a correct binomial model, ft their answer to part (b)		
	2 nd M1 for a correct probability statement of $1 - P(M \leq 1)$ dep on a binomial selected			
	A1cso for answer in range [0.04139, 0.04154] dep on use of B(8, "0.0419") or better			
(d)	1 st M1 for selecting a Po(6.3) model			
	2 nd M1 for a correct probability statement using their Poisson model and their CR in (a) which may have just one tail.			
	A1 for awrt 0.945			



Question	Scheme	Marks	AOs
1(a)(i)	$X \sim \text{Po}(24)$	B1	3.4
	$P(X = 26) = 0.071912\dots$ awrt 0.0719	B1	1.1b
		(2)	
(ii)	$P(X \geq 21) = 1 - P(X \leq 20) [= 1 - 0.24263\dots]$	M1	3.4
	$= 0.75736\dots$ awrt 0.757	A1	1.1b
		(2)	
(b)	$H_0: \lambda = 2$ [$\mu = 16$] $H_1: \lambda < 2$ [$\mu < 16$]	B1	2.5
	$P(Y \leq 10 Y \sim \text{Po}(16)) = 0.077396\dots$ awrt 0.0774	B1	1.1b
	Not significant / Do not reject H_0 / 10 is not in the CR	M1	1.1b
	There is <u>not</u> sufficient evidence to suggest a decrease/change in the rate of <u>customers</u> entering Jeff's supermarket.	A1	2.2b
		(4)	
(c)	Use of $\text{Po}(8)$ to attempt critical region	M1	2.1
	Critical region is $Y \leq 3 / H_0$ is not rejected when $Y \geq 4$	A1	1.1b
	True distribution is $W \sim \text{Po}(4)$	B1	2.1
	$P(W \geq 4 W \sim \text{Po}(4)) = 1 - P(W \leq 3) [= 1 - 0.43347\dots]$	M1	1.1b
	$= 0.56652\dots$ awrt 0.567	A1	1.1b
		(5)	
(13 marks)			
Notes			
(a)(i) (ii)	B1: For realising the distribution is $\text{Po}(24)$ (May be seen or implied in part (ii)) B1: awrt 0.0719 M1: Writing or using $1 - P(X \leq 20)$ A1: awrt 0.757		
(b)	B1: Both hypotheses correct (must use μ or λ) B1: awrt 0.0774 Allow awrt 0.08 from a correct probability statement. allow CR: $X \leq 9$ M1: Correct non-contextual conclusion (may be implied by correct contextual conclusion). Allow a f.t. comparison of 'their p ' with 0.05 (Ignore any contradictory contextual comments for this mark) A1: A fully correct solution drawing a correct inference in context with all previous marks in (b) scored.		
(c)	M1: Use of $\text{Po}(8)$ to attempt critical region [$P(Y \leq 3) = 0.0423\dots$ $P(Y \leq 4) = 0.0996\dots$] A1: Finding critical region for the test $Y \leq 3$ which must come from $\text{Po}(8)$. B1: Identifying the need to use $\text{Po}(4)$ as the true distribution. Allow $\text{Po}(4)$ seen or used for this mark. M1: Writing or using $P(W \geq 4)$ or $1 - P(W \leq 3)$ from $\text{Po}(4)$. Allow f.t. on their identified CR but must be using $\text{Po}(4)$ A1: awrt 0.567		

Question	Scheme	Marks	AOs
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Qu	Scheme	Marks	AO												
4(a)	[T = no. of oak trees in a square] $T \sim \text{Binomial}$ $T \sim B(6, p)$	M1 A1 (2)	3.3 1.1b												
(b)	Expected frequency for 6 is less than 5 so pool: new $E_i = 13.08$ <table border="1"><tr><td>$\frac{(O_i - E_i)^2}{E_i}$</td><td>0.051</td><td>2.51</td><td>0.0654</td><td>3.84</td><td>1.85</td></tr><tr><td>$\frac{O_i^2}{E_i}$</td><td>4.521</td><td>29.617</td><td>21.805</td><td>7.599</td><td>24.771</td></tr></table> $\sum \frac{(O_i - E_i)^2}{E_i} = 8.313$ p needed estimating ($\hat{p} = 0.55$) so $\nu = 5 - 2 = 3$; cv 7.815 Significant result, so Liam's <u>model is not suitable</u>	$\frac{(O_i - E_i)^2}{E_i}$	0.051	2.51	0.0654	3.84	1.85	$\frac{O_i^2}{E_i}$	4.521	29.617	21.805	7.599	24.771	M1 M1,A1 B1,B1ft M1,A1 (7)	2.1 1.1b x2 1.1b x2 1.1b2.2b
$\frac{(O_i - E_i)^2}{E_i}$	0.051	2.51	0.0654	3.84	1.85										
$\frac{O_i^2}{E_i}$	4.521	29.617	21.805	7.599	24.771										
(c)	[R = no. of oak trees in a square for Simone's model] $R \sim \text{Po}(3.3)$ Correct expression for s or t using Poisson $s = \underline{17.67}$ and $t = \underline{9.62}$	M1 M1 A1,A1 (4)	3.3 3.4 1.1b x2												
(d)	H_0 : Poisson is a good fit (for no. of oak trees per square) H_1 : Poisson is not a good fit (for no. of oak trees per square)	B1 (1)	2.5												
(e)	No pooling needed so degrees of freedom is $6 - 2 = 4$ Critical value is 9.488 (accept 9.49) Not significant so Poisson (or Simone's) model is suitable	B1 B1 B1 (3)	1.1b 1.1a 2.2b												
(f)	Poisson model has better fit so suggests that oak trees occur at random <u>Or</u> binomial suggests deliberately planted or cultivated Therefore the forest is likely to be wild not cultivated	B1 B1 (2)	2.2b 3.5a												
		(19 marks)													
Notes															
(a)	M1 for choosing binomial A1 for $B(6, p)$ can be in words and allow $B(6, 0.55)$														
(b)	1 st M1 for pooling last 2 classes ($E_i = 13.08$ but accept 13.1) 2 nd M1 for at least 3 correct values or expressions. Either row to at least 2 sf 1 st A1 for awrt 8.31 (8.31 gets 3/3) [NB no pooling gives awrt 16.8458.. and implies M0M1A0] 1 st B1 for 3 degrees of freedom 2 nd B1ft for critical value of 7.815 (e.g. $\nu = 4$ use 9.488) 3 rd M1 for a correct conclusion (non-contextual ignore any contradictory contextual comments for this mark) based on their cv and their test statistic This mark can be implied by a fully correct solution ending with correct contextual conclusion 2 nd A1 for correct conclusion in context with all other marks scored														
(c)	1 st M1 for selecting a correct model $\text{Po}(3.3)$ [Allow $\text{Po}(\text{awrt } 3.3)$] 2 nd M1 for use of the model with an expression or correct value for s or t 1 st A1 for one correct 2 nd A1 for both correct (allow awrt 2dp)														
(d)	B1 for correct hypotheses must mention Poisson: use of $\text{Po}(3.3)$ is B0														
(e)	1 st B1 for correct degrees of freedom $\nu = 4$ only 2 nd B1 for selecting correct critical value (9.488 only) 3 rd B1 for <u>not significant</u> conclusion based on 8.749 vs their cv (condone use of $\text{Po}(3.3)$ here)														
(f)	1 st B1 for choosing Poisson as better <u>or</u> stating Poisson implies wild <u>or</u> bino'l implies cultivated 2 nd B1 (dep on rejecting bin and accepting Poisson) for clearly stating woodland is wild If the tests give the same results then 2 nd B0 automatically														

Q	Scheme	M	AOs
5(a)	One correct assumption in context from below	B1	3.5b
	Two correct assumptions from below, with goals or matches mentioned at least once - Goals are scored at a <u>constant rate</u> - Goals are scored <u>independently/randomly</u> or matches are <u>independent</u> - Goals are scored not scored <u>simultaneously</u> or Goals are scored <u>singly</u>	B1	3.5b
		(2)	
(b)	$A_{0.5} \sim \text{Po}(0.9)$ and $A_1 \sim \text{Po}(1.8)$	B1	3.3
	$P(A_{0.5} = 2 A_1 = 3) = \frac{P(A_{0.5} = 2) \times P(A_{0.5} = 1)}{P(A_1 = 3)}$	M1	3.4
	$P(A_{0.5} = 2 A_1 = 3) = \frac{\frac{0.9^2 e^{-0.9}}{2!} \times \frac{0.9 e^{-0.9}}{1!}}{\frac{1.8^3 e^{-1.8}}{3!}} \text{ or } \frac{0.164... \times 0.365...}{0.160...}$	M1	1.1b
	$P(A_{0.5} = 2 A_1 = 3) = \frac{3}{8} \quad \frac{3}{8} \text{ or exact equivalent}$	A1	1.1b
		(4)	
(c)(i)	$X \sim B(4, 0.55)$	B1	3.3
(c)(ii)	$E(X) = '4' \times '0.55' [=2.2] \text{ or } \text{Var}(X) = '4' \times '0.55' \times (1 - '0.55') [=0.99]$	M1	2.1
	$\bar{X} \approx N\left(2.2, \frac{0.99}{40}\right)$	M1	3.3
	$P(\bar{X} > 2)$ awrt 0.898	A1	3.4
		(4)	
(10 marks)			
Notes:			
(a)	B1:	One contextual correct assumption relating to <u>independence/constant rate/singly</u> Must mention <u>goals or match</u> , or equivalent context.	
	B1:	Two correct contextual assumptions with goals/matches mentioned at least once. Assumptions relating to probability or number of goals are B0, but do not penalise if two correct assumptions also given.	
(b)	B1:	Stating or using both correct Poisson distributions [0.164... or 0.365... implies Po(0.9), 0.160... implies Po(1.8). Both are required for this mark] or writing or using B(3, 0.5)	
	M1:	Correct use of conditional probability formula. Implied by $\frac{0.164... \times 0.365...}{0.160...}$ Or writing or using any binomial distribution and $P(X = 2)$	
	M1:	Correct expression with probabilities or writing or using B(3, 0.5) and $P(X = 2)$	
	A1:	Correct exact answer. Do not award if there is clear evidence of rounding.	
(c)(i)	B1	Stating correct binomial distribution	
(c)(ii)	M1:	Correct method to find the mean or variance of X (a mean of 2.2 from Poisson is M1) ft their n and p	
	M1:	Correct approximate normal distribution [condone using X not $\bar{X}$]. Allow variance awrt 0.0248	
	A1:	awrt 0.898 NB: awrt 0.898 implies the M1M1A1	



Question	Scheme							Marks	AOs														
4(a)	$4E(N) + 2 = 14.8$ or $E(N) = 3.2$							M1	3.1a														
	$0.2 + 0.1 + 0.75 + 4b + 5c = 3.2$							M1	1.1b														
	$\frac{c}{0.25 + b + c} = 0.5$ or $0.25 = c - b$							M1	3.1a														
	$b = 0.1$ and $c = 0.35$																						
	$E(N^2) = 1 \times 0.2 + 4 \times 0.05 + 9 \times 0.25 + 16 \times "0.1" + 25 \times "0.35" [= 13]$							M1	1.1b														
	$\text{Var}(N) = "13" - "3.2" ^2$							dM1	1.1b														
	$= 2.76$ *							A1*	2.1														
								(6)															
(b)	<table border="1"><tr><td>fee</td><td>0</td><td>50</td><td>70</td><td>90</td><td>100</td><td>100</td></tr><tr><td>$P(N = n)$</td><td>a</td><td>0.2</td><td>0.05</td><td>0.25</td><td>b</td><td>c</td></tr></table>							fee	0	50	70	90	100	100	$P(N = n)$	a	0.2	0.05	0.25	b	c	M1	3.3
	fee	0	50	70	90	100	100																
	$P(N = n)$	a	0.2	0.05	0.25	b	c																
	$50 \times 0.2 + 70 \times 0.05 + 90 \times 0.25 + 100 \times "0.1" + 100 \times "0.35"$							M1	1.1b														
$= 81p$							A1	1.1b															
							(3)																
(c)	Poisson distribution will assign substantial probability to $N > 5$							B1	3.5b														
								(1)															
(10 marks)																							
Notes																							
(a)	M1:	For using the given information to find $E(N)$																					
		ALT $a + b + c = 0.5$ oe																					
	M1:	For use of $\sum nP(N = n) = "3.2"$ At least 3 terms correct																					
		ALT $\sum (4n + 2)P(N = n) = 14.8 \Rightarrow 2a + 1.2 + 0.5 + 3.5 + 18b + 22c = 14.8$ At least 3 terms correct																					
	M1:	Forming an equation in b and c using conditional probability																					
	M1:	For using $\sum n^2P(N = n)$ Allow with the letters b and c																					
	dM1:	Dependent on previous method mark. Correct method to find $\text{Var}(N)$																					
	A1*:	All previous marks must be awarded and 2.76 stated																					
(b)	M1:	Setting up a new model with the correct fees. At least 3 terms correct. Allow 0.5, 0.7, 0.9, 1																					
	M1:	Correct method for calculating $E(\text{fee})$ Allow with the letters b and c																					
	A1:	81[p] No units needed. Allow 0.81 if fees are in pounds																					
(c)	B1:	A correct limitation.																					

Qu.	Scheme	Marks	AOs												
5(a)	$p = \frac{(0)+11+14+6+(0)+5+(0)}{6 \times 40}$	M1	2.1												
	$p = \underline{0.15}^*$	A1*cs0	1.1b												
		(2)													
(b)	$X \sim B(6, 0.15)$	M1	3.4												
	<table><tr><td>x</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr><tr><td>$40 \times P(X = x)$</td><td>7.04...</td><td>1.65...</td><td>0.219...</td><td>0.015...</td><td>0.00...</td></tr></table>			x	2	3	4	5	6	$40 \times P(X = x)$	7.04...	1.65...	0.219...	0.015...	0.00...
	x			2	3	4	5	6							
	$40 \times P(X = x)$	7.04...	1.65...	0.219...	0.015...	0.00...									
	Require $40 \times P(X \geq k) > 5$ Exp. frequency for $X \geq 2 = 8.94... / X \geq 3 = 1.89...$	M1	1.1b												
	Combine last 5 cells / only 3 cells in total	A1	2.2a												
	2 is subtracted (as there are 2 restrictions) and the proportion used from data (and 1 equal totals)	B1	2.4												
	$3 - 2 = 1$ degree of freedom	A1	1.1b												
	H_0 : Binomial distribution is a suitable model H_1 : Binomial distribution is not a suitable model	B1	3.4												
	Critical value $\chi^2_{(1,0.10)} = 2.705$ or 2.706	B1ft	1.1b												
	Test statistic is not in the critical region, insufficient evidence to reject H_0 ($2.689 < 2.705/6$) Data are consistent with binomial/engineer's/suggested model.	B1ft	3.5a												
		(8)													
(c)	The total amount/proportion of defective pins remains the same.	M1	2.4												
	The cells for $X \geq 2$ are still combined in the test.	M1	1.1b												
	So there is no change to the value of the test statistic.	A1	2.2a												
		(3)													
(13 marks)															
Notes															
(a)	M1: Correct expression for p (may be seen in stages). Allow $\frac{36}{240}$ but not $\frac{6}{40}$ on its own A1*cs0: $p = 0.15$ stated and no incorrect working seen														
(b)	M1: Attempting to find expected frequencies, at least 2 correct trunc. or rounded 1dp M1: Recognising need to combine cells (Sight of awrt 8.94 implies M1M1) A1: Combining cells for $X \geq 2$ (to make 3 cells) B1: Justifying why 2 is subtracted with p being calculated from data A1: 1 degree of freedom B1: Correct hypotheses (0.15 must not be included) Allow engineer's model. B1ft: Correct critical value (ft their df) May see $\chi^2_{(2,0.10)} = 4.605$ or $\chi^2_{(3,0.10)} = 6.251$ B1ft: Correct inference (ft comparison of their CV with 2.689). Condone $p = 0.15$ included here. Do not allow contradictory statements to score here. Hypotheses must be correct way round.														
(c)	M1: Determining the number ($N=36$)/proportion ($p=0.15$) of defective pins has not changed. e.g. $11 + 12 + 9 + 4 = 36$. But not $7 + 2 + 1 = 6 + 3 + 1$ M1: Understanding the cells for $X \geq 2$ are still combined in the test A1: (dep on both M1s) Concluding that there is no change to the value of the test statistic.														