

January 2018

Question		
4		
(c)	$H_0 : p = 0.1$ $H_1 : p < 0.1$ $Y \sim B(40, 0.1)$ $P(Y \leq 1) = 0.080473\dots$ Do not reject H_0 / Not significant The <u>proportion</u> of customers buying more than 2 bags of sweets is <u>not less than 10%/not less than the shop's claim</u> or The <u>shop's claim</u> is not rejected	B1 M1 dM1 A1cso (4)

January 2018

Question		
6.		
(b)	$[H_0 : \lambda = 9$ $H_1 : \lambda > 9]$ $[B \sim \text{Po}(9)]$ $P(B \leq 14) = 0.9585 / P(B \geq 15) = 0.0415 (< 0.05)$ $B \geq 15$	M1 A1 (2)

June 2018

Question Number	Scheme	Marks
7(a)	$X \sim B(25, 0.40)$ $P(X \leq 3) = 0.0024$ (calc: 0.002366768....) accept $P(X < 4)$ $P(X \geq 17) = 0.0043$ (calc: 0.004326388....) accept $P(X > 16)$ CR: $X \leq 3$, $X \geq 17$ (o.e.)	M1 A1 A1 A1, A1 (5)
(b)	0.0067	B1 ft (1)
(c)	$H_0: p = 0.4$ $H_1 : p < 0.4$ $[R \sim B(50, 0.4)]$ $P(R \leq 8) = 0.0002305\dots$ awrt 0.0002 Reject H_0 Evidence that: the <u>changes</u> have been <u>successful</u> or there are <u>fewer red sweets</u> (oe)	B1 M1 A1 A1cso (4)

October 2018

Question	
1	
(b)	$H_0: \lambda = 6$ (or 9) $H_1: \lambda > 6$ (or 9) $Y \sim \text{Po}(9)$ $P(Y \geq 14) = 1 - P(Y \leq 13) = 1 - 0.9261 = 0.0739$ / $P(Y \geq 15) = 0.0415$, CR: $Y \geq 15$ Do not reject H_0 / Not significant / 14 is not in the critical region There is not enough evidence to suggest that the rate of calls for reservations has increased.
	B1 M1A1 dM1 A1cso (5)

October 2018

Question	
Question	
4	
(d)	$X \sim B(12, 0.2)$ $P(X \leq 4) = 0.9274$ $P(X \geq 5) = 0.0726 < 0.10$ $P(X \leq 3) = 0.7946$ $P(X \geq 4) = 0.2054 > 0.10$ CR: $X \geq 5$
(e)	0.0726
	M1 A1 B1ft (2) (1)

January 2019

Question Number	Scheme	Marks
4. (a)	$H_0: p = 0.35$ $H_1: p > 0.35$ Probability route CR route $P(X \geq 11) = 1 - P(X \leq 10) [= 1 - 0.9468]$ $P(X \leq 11) = 0.9804$ = 0.0532 $P(X \geq 12) = 0.0196$ CR: $X \geq 12$ Do not Reject H_0 or not significant or 11 does not lie in the CR <u>Hadi's</u> belief is <u>not</u> supported or the <u>proportion</u> of customers paying by <u>credit card</u> is not greater than 35%.	B1 M1 A1 dM1 A1cso (5)

Question Number	Scheme	Marks
4(a)	Let X = number of traffic accidents (in 12 months) $H_0: \lambda = 2.5$ (or $\lambda = 10$) $H_1: \lambda \neq 2.5$ (or $\lambda \neq 10$) Under $H_0: X \sim \text{Po}(2.5)$ Either: $P(X \geq 6) = 1 - P(X \leq 5)$ $= 1 - 0.9580$ $= 0.0420$ 4.2% > 2.5% so not significant, do not reject H_0 There is no evidence of a change in the rate of accidents, OR supermarket manager's claim is not rejected.	B1 M1 A1 dM1 A1 (5)
(b)	Test is now one-tailed, or now have $H_1: \lambda > 2.5$ (or $\lambda > 10$) 4.2% < 5% or $[P(X \geq 6) = 0.0420 \text{ so}] \text{ C.R is } X \geq 6.$ so result is significant, reject H_0 There is evidence of an increase in the rate of accidents, OR resident's claim is supported.	B1 M1ft A1 (3)

Question Number		
6		
(e)	$H_0: p = 0.3 \quad H_1: p < 0.3$ Under $H_0, Y \sim B(20, 0.3)$ $P(Y \leq 2) = 0.0355 \quad P(Y \leq 3) = 0.1071$ C.R. is $Y \leq 2$	B1 M1 A1cao (3)
(f)	3.55% or 0.0355	B1 (1)

Question

3

(c)	$H_0 : \lambda = 0.3$ or $\mu = 50.4$	B1
	$H_1 : \lambda < 0.3$ or $\mu < 50.4$	
	$W \sim \text{Po}(50.4)$ can be approximated by $N(50.4, 50.4)$	B1
	$P(W \leq 38) \approx P\left(Z < \frac{38.5 - 50.4}{\sqrt{50.4}}\right)$	M1 M1
	$\approx P(Z < -1.676...) = 0.0468$ (calc) $\approx P(Z < -1.68) = 0.0465$ (tables)	A1
	Reject H_0 / significant	dM1
	There is evidence of a <u>decrease</u> in the <u>rate</u> of <u>hacking attempts</u> or <u>Saira's belief</u> is <u>supported</u> .	A1cso
		(7)

Question

7

(c)	$H_0 : p = 0.25$ $H_1 : p < 0.25$	B1
	$Y \sim B(25, 0.25)$ and $P(Y \leq 3) =$	M1
	0.0962	A1
	or $P(Y \leq 2) = \text{awrt } 0.0321$	dM1
	CR $Y \leq 2$	A1cso
	Do not reject H_0 / not significant	
	There is <u>not</u> enough evidence to suggest that the model <u>overestimates</u> the <u>proportion</u> of <u>queuing</u> more than 4 minutes/ <u>Olivia's belief</u> is <u>not supported</u> .	

Question

2

(b)	$H_0 : p = 0.35$ $H_1 : p > 0.35$	B1
	$L \sim B(50, 0.35)$ $P(L \geq 25) = 1 - P(L \leq 24)$	M1
	$= 1 - 0.9793$	
	$= 0.0207$	A1
	CR $L \geq 24$	dM1
	Reject H_0 or Significant or 25 does lie in the critical region	
	There is evidence to support Kiyoshi's belief or <u>or</u> that the proportion/number of large eggs has increased after adding the supplement	A1cso
		(5)

Question Number	Scheme		Marks
5(a)	$X \sim \text{Po}(4)$		M1
	$P(X = 0) = 0.0183$	$P(X \geq 8) = 0.0511$	
	$P(X \leq 1) = 0.0916$	$P(X \geq 9) = 0.0214$	
	CR $X = 0$ oe	$X \geq 9$ oe	A1A1
			(3)
(b)	3.97%		B1
			(1)
(c)	6 is not in the critical region – the data collected are consistent with Chris’s claim		B1ft
			(1)
(d)	$\lambda = \frac{2n}{9}$		B1
	$1 - P(Y = 0) > 0.9$		M1
	$1 - e^{-\frac{2n}{9}} > 0.9$		
	$e^{-\frac{2n}{9}} < 0.1$		
	$n = 10$ and $e^{-\frac{2n}{9}} = 0.1083...$	or $-\frac{2n}{9} < \ln 0.1$	dM1
	$n = 11$	$e^{-\frac{2n}{9}} = 0.08677...$	
	Therefore $n = 11$		A1 cao
(e)	$H_0 : \lambda = 10$ $H_1 : \lambda < 10$		B1
	$[W \sim \text{Po}(10) \ P(W \leq 5) =] 0.0671$	or CR $W \leq 4$	B1
	Do not reject H_0 or insignificant or 5 does not lie in the critical region		M1
	There is no significant evidence that the mean number/rate of whales has decreased.		A1cso
			(4)

October 2020

Question Number		
3		
(c)	$H_0: p = 0.45$	$H_1: p < 0.45$
	$Y \sim B(30, 0.45)$ therefore $P(Y \leq 8) = 0.03...$	or CR $Y \leq 8$
	8 is in the critical region or Reject H_0 oe or significant	
	therefore the data collected supports the manufacturer’s claim .	

October 2020

Question Number		
4		
(c)	$H_0 : \lambda = 9$ $H_1 : \lambda > 9$	B1
	$M \sim \text{Po}(9)$ $P(M \geq 11) = 1 - P(M \leq 10)$	M1
	$= 0.294$	or CR $M \geq 15$
	Accept H_0 or insignificant or 11 does not lie in the critical region	
	There is insufficient evidence to support Juan’s belief	

January 2021

Question Number
1

(e)	$H_0: p = 0.05, H_1: p > 0.05$		B1
	Using $C \sim B(25, 0.05)$ and $P(C \geq 4)$	Using $D \sim B(25, 0.95)$ and $P(D \leq 21)$	M1
	$P(C \geq 4) = 0.0341 / \text{CR } C \geq 4$	$P(D \leq 21) = 0.0341 / \text{CR } D \leq 21$	A1
	Evidence to reject H_0 , in the CR, significant		dM1
	There is evidence that the proportion of oysters not surviving has increased (oe)/ Jim's belief is supported.		A1cso
			(5)

January 2021

Question Number
3

(d)	$H_0: \lambda = 7 \quad H_1: \lambda > 7$		B1
	$P(X \geq 15) = 1 - P(X \leq 14)$	$P(X \geq 14) = 0.0128$	M1
	$= 1 - 0.9943$	$P(X \geq 15) = 0.0057$	
	$= 0.0057$	CR $X \geq 15$	A1
	Reject H_0 , in the CR, Significant		dM1
	There is evidence that the number of water fleas per 100 ml of the pond water has increased		A1
			(5)

June 2021

Question Number
1.

(d)	[V = no. of seeds that do not germinate $V \sim B(100, 0.05)$ approximates to] $V \sim \text{Po}(5)$			M1A1
	$P(V \geq 8) = 1 - P(V \leq 7)$	CR for 1-tail in (c)	CR for 2-tail in (c)	M1
	$= 1 - 0.8666$	$P(V \geq 9) = 0.0681$	$P(V \geq 10) = 0.0318$	
	$= 0.1334$	$P(V \geq 10) = 0.0318$	$P(V \geq 11) = 0.0137$	A1
		CR $V \geq 10$ oe	CR $V \geq 11$ oe	dM1
	Accept H_0 <u>or</u> not significant <u>or</u> 8 does not lie in the critical region			A1cso
	Data consistent with Spain's claim <u>or</u> Insufficient evidence for Jem's belief			(6)

June 2021

Question Number
2.

(e)	$H_0: \lambda = 9 \quad H_1: \lambda > 9$	B1
	$R \sim \text{Po}(0.9 \times 10)$ and $[P(R \geq 13)] = 1 - P(R \leq 12) [= 1 - 0.8758]$	M1
	$P(R \leq 13) = 0.9261$ <u>or</u> $P(R \geq 14) = 0.0739$ <u>or</u> $P(R \leq 14) = 0.9585$ <u>or</u> $P(R \geq 15) = 0.0415$	A1
	$[P(R \geq 13)] = 0.1242$ awrt 0.124 <u>or</u> CR $R \geq 15$ (oe)	M1
	so insufficient evidence to reject H_0 /not significant/ not in critical region	A1
	There is insufficient evidence that the rate at which faults occur is higher for Rhiannon	(5)

October 2021

Question
Number

1

(d)	$H_0: p = 0.35 \quad H_1: p > 0.35$	B1
	Let Y be the number of customers who do not buy free range eggs. $Y \sim N(70, 45.5)$	M1
	$P(Y \leq 86) \approx P\left(Z > \frac{85.5 - 70}{\sqrt{45.5}}\right) \quad \text{or} \quad \pm \frac{x - 0.5 - 70}{\sqrt{45.5}} = 1.6449$	M1 M1
	$\approx 0.01078\dots \quad \text{or} \quad 81.595\dots$	A1
	There is evidence to reject H_0 . In the critical region	dM1
	There is evidence to support the manager's belief / There is evidence to support the <u>proportion</u> of customers who <u>do not buy free range eggs</u> is <u>more than 35%</u> (o.e)	A1
		(7)

October 2021

Question
Number

4

(f)	$J \sim \text{Po}(9)$	M1
	$P(J \leq 13) = 0.9261$	
	$P(J \leq 14) = 0.9585$	
	So critical region is $J \geq 15$	A1
		(2)

January 2022

Question Number	Scheme	Marks
3 (a)	We can assume breakdowns are [rare], independent events occurring at a constant rate.	B1
		(1)
(b)	$H_0: \lambda = 8 \quad H_1: \lambda \neq 8$	B1
		(1)
(c)	$X \sim \text{Po}(8)$	
	$P(X \leq 2) = 0.0138 \text{ oe} \quad P(X \leq 3) = 0.0424 \text{ oe}$	M1
	$P(X \geq 14) = 0.0342 \text{ oe} \quad P(X \geq 15) = 0.0173 \text{ oe}$	M1
	$X \leq 2 \cup X \geq 15 \text{ oe}$	A1
		(3)
(d)	“0.0138” + “0.0173”	M1
	= “0.0311”	A1ft
		(2)
(e)	“[4 is] not in the critical region”	M1
	So there is insufficient evidence that refurbishment has changed the mean breakdown rate	A1
		(2)

Question Number
5

(e)	$H_0 : p = 0.75 \quad H_1 : p \neq 0.75$	B1
	$B(96, 0.75) \Rightarrow N(72, 18)$	B1
	$Z = \frac{67.5 - 72}{\sqrt{18}} \quad \text{or} \quad \frac{x \pm 0.5 - 72}{\sqrt{18}}$	M1
	$= -1.06066... \quad \text{or} \quad \frac{x + 0.5 - 72}{\sqrt{18}} < -1.96 \quad \text{or} \quad \frac{x - 0.5 - 72}{\sqrt{18}} > 1.96$	A1
	$P(z < -1.06) = 0.1444... / 0.1446 \quad \text{or} \quad CR < 63.2 \quad \text{awrt } 0.144 \text{ or } 0.145$	A1
	There is insufficient evidence to reject H_0	dM1
	Insufficient evidence against Jaymini's claim	A1

(7)

June 2022

Question	Scheme	Marks
4. (a)	$[P(Y = 0) < 0.05]$	
	$(1 - 0.07)^n < 0.05$	M1
	$n \log(0.93) < \log(0.05)$	M1
	$n > 41.28... \quad n = 42$	A1
		(3)
(b)	$H_0: p = 0.08 \quad H_1: p \neq 0.08$	B1
	$X \sim B(75, 0.08) \rightarrow \text{Po}(6)$	M1
	$P(X \leq 11) = 1 - P(X \geq 10)$	M1
	$= 1 - 0.9574 = 0.0426 [> 0.025]$	A1
	Do not Reject H_0 or not significant or 11 does not lie in the CR	dM1
	There is not significant evidence to suggest that the proportion of pears weighing more than 180g has changed	A1
		(6)

Question Number	Scheme	Marks
3(a)	$H_0: p = 0.35 \quad H_1: p \neq 0.35$	B1
	$P(X, 8) = \text{awrt } 0.0303 \text{ or } P(X \dots 21) = \text{awrt } 0.0173 \text{ or } P(X, 20) = \text{awrt } 0.9827$	M1
	$[P(X, 8) =] \text{awrt } 0.0303 \text{ and } [P(X \dots 21) =] \text{awrt } 0.0173$	A1
	CR $X, 8$ and $X \dots 21$	A1
		(4)
(b)	0.0476	B1ft
		(1)
(c)	$H_0: p = 0.028 \quad H_1: p > 0.028$	B1
	$Y \square B(250, 0.028) \Rightarrow Y \square \text{Po}(7)$	M1
	$P(Y \dots 11) = 1 - P(Y, 10) \text{ or } P(Y \dots 13) = 1 - 0.973$	M1
	$= 0.0985 \text{ or } \text{Critical region } Y \dots 13$	A1
	There is insufficient evidence to suggest that the <u>proportion</u> of sunflower seeds that grow to a height of more than 3 metres is now <u>greater</u> than 0.028	A1
		(5)

Question Number		
1		
(d)	$H_0: \lambda = '4' \quad H_1: \lambda > '4'$	B1ft
	$P(X \geq 7) = 1 - P(X \leq 6) \text{ or } P(X \geq 9) = 1 - P(X \leq 8) = 0.0214$	M1
	$= 0.1107 \text{ or } \text{CR } X \geq 9 \text{ awrt } 0.111$	A1
	Not significant/Do not reject H_0 /Not in the critical region	M1
	There is insufficient evidence of an <u>increase</u> in <u>sales</u> following the appearance of the advert/ <u>manager's belief</u> is not supported.	dA1
		(5)

Question Number		
3		
(b)	$H_0: p = 0.1 \quad H_1: p < 0.1$	B1
	$X \sim B(50, 0.1)$	
	$P(X \leq 2) = 0.1117 \text{ or } \text{CR } X \leq 1$	B1
	Do not reject H_0 /Not in the critical region	M1
	There is insufficient evidence to suggest that this result supports the managing <u>director's claim</u> /not enough evidence to suggest a <u>reduction</u> in the probability of a tennis ball <u>failing</u> the bounce <u>test</u>	A1
		(4)
(c)	$X \sim B(n, 0.1)$ and we reject H_0 if $P(X = 0) < 0.01$	
	$P(X = 0) = [{}^nC_0 \times 0.1^0] \times 0.9^n [< 0.01]$	M1
	$0.9^{44} = 0.00969... [< 0.01]$	$n > \frac{\ln 0.01}{\ln 0.9} \Rightarrow n > 43.7$
	$n = 44$	A1
		(3)

Question Number		
4.		
(c)(i)	$H_0 : p = 0.05 \quad H_1 : p < 0.05$ $D \sim B(30, 0.05)$ $P(D = 0) = 0.2146$ Do not reject H_0 / not significant The <u>manufacturer's</u> claim is not supported/There is not enough evidence to suggest that the <u>proportion</u> (oe) of candle <u>holders</u> with minor <u>defects</u> is less than 5%/ <u>Charlie's</u> claim is supported	B1 M1 A1 M1 A1
(ii)	Impossible to reject H_0 (since $P(D = 0) > 0.05$)	B1

Question Number			
5			
(c)	$H_0 : \lambda = 6 \quad H_1 : \lambda > 6$		B1
	$P(X \geq 12) = 1 - P(X \leq 11) = [1 - 0.9799] \quad \text{or} \quad P(X \geq 11) = 1 - P(X \leq 10) = [1 - 0.9574]$		M1
	$= 0.0201 \quad \text{or} \quad CR \geq 11$		A1
	Reject H_0 /In the CR/Significant		M1
	There is sufficient evidence to suggest that the mean number of complaints received is greater than 6 per week		A1ft
			(5)
(d)	$H_0 : \lambda = 6 \quad H_1 : \lambda < 6$		B1
	6 week period is $Po(36) \Rightarrow N(36, 36)$		B1
	$P(Y \leq 26) \approx P(Y < 26.5) = P\left(Z < \frac{26.5 - 36}{6}\right) \quad \text{or} \quad \frac{x + 0.5 - 36}{\sqrt{36}} < -1.6449$		M1 M1
	$[P(Z < -1.583...)] = 0.0571$ (Calculator 0.05667...) or $x < 25.63...$ awrt 0.057 awrt 25.6		A1
	Do not reject H_0 /Not in the CR/Not significant		M1
	There is insufficient evidence to suggest that the mean number of complaints received after the changes made is less than 6 per week		A1ft
			(7)

Question Number	Scheme	Marks
3 (a)	The vacuum tubes shatter independently	B1
	The probability of a vacuum tube shattering is constant	B1
		(2)
(b)	$C \sim B(15, 0.35)$ plus $[P(C = 9) = 0.0142 \text{ or } P(C = 10) = 0.0124 \text{ or } P(C = 9) = 0.9876]$	M1
	Critical regions $[0, 1] \text{ or } [10, 15]$	M1
	$[0, 1] \text{ or } [10, 15]$ plus $P(C = 9) = 0.0142 \text{ and } P(C = 10) = 0.0124$	A1
		(3)
(c)	0.0266	B1ft
		(1)
(d)	[4 is not in the CR therefore] there is no evidence to reject Rowan's belief	B1ft
		(1)
(e)	$F \sim B(40, 0.35)$	
	$H_0: p = 0.35 \text{ and } H_1: p < 0.35$	B1
	$P(F = 8) = 0.0303 \text{ or CR } F = 8$	M1A1
	Sufficient evidence to reject H_0 or significant or 8 lies in the Critical region	M1
	There is sufficient evidence to support that the proportion of type <i>B</i> vacuum tubes that shatter when exposed to alternating high and low temperatures is less than 35%	A1
		(5)