

Qu	Scheme	Marks	AO
4. (a)	[$R = \text{no. of red beads in Aliya's bracelet}$] $R \sim B(18, 0.14)$	B1 (1)	3.3
(b)(i)	$P(R = 1) = 0.19403\dots$ awrt 0.194	B1	1.1b
(ii)	$P(R \geq 4) = 1 - P(R \leq 3) = 1 - [0.76184\dots]$ $= 0.2381588\dots$ awrt 0.238	M1 A1 (3)	3.4 1.1b
(c)	Requires $p = 0.14$ to be constant so need a large number of beads in the sack to ensure that removing 18 beads does not appreciably affect this probability, then it could be suitable.	B1 (1)	3.5b
(d)	$H_0 : p = 0.14$ $H_1 : p \neq 0.14$ [$X = \text{number of red beads in the sample}$] $X \sim B(75, 0.14)$ $P(X \leq 4) = 0.01506\dots$ or if $B(75, 0.14)$ seen awrt 0.02 { $0.02 < 0.025$ so significant <u>or</u> reject H_0 } There is evidence that the proportion of red beads has changed	B1 M1 A1 A1 (4)	2.5 3.3 3.4 2.2b
(e)	p -value is $2 \times "0.01506\dots" = 0.030123\dots =$ awrt 0.03	B1ft (1)	1.1b
(10 marks)			
Notes			
(a)	B1 for $B(18, 0.14)$ accept in words e.g. <u>binomial</u> with $n = 18$ and $p = 0.14$		
(b)(i)	B1 for awrt 0.194		
(ii)	M1 for interpreting "at least 4" Need $1 - P(R \leq 3)$ <u>and</u> $1 - p$ [$0 < p < 1$] $P(R = 3) = 0.233\dots$ OK A1 for awrt 0.238		
(c)	B1 for mention of <u>large number of beads</u> and need for <u>$p = 0.14$ to be constant</u> for it to be suitable. Do NOT accept e.g. "events are independent"		
(d)	B1 for both hypotheses correct with use of p or π M1 for selecting a suitable model: sight or correct use of $B(75, 0.14)$ May be implied by sight of 0.015 or better <u>or</u> [$P(X > 4) =$] 0.9849... i.e. 0.985 or better 1 st A1 for use of the correct model awrt 0.015 (accept awrt 0.02 following a correct expression) Allow 1 st A1 for awrt 0.985 <u>only if</u> correct comparison with 0.975 is seen. Sight of $B(75, 0.14)$ and $P(X \leq 4) =$ awrt 0.02 scores M1A1 <u>No sight</u> of $B(75, 0.14)$ <u>but</u> sight of awrt 0.015 scores M1(\Rightarrow)A1[Condone $P(X = 4) = \dots$] 2 nd A1 (dep on M1A1) for a correct conclusion in context mentioning "proportion", "red" and "changed"		
NB	If there is a statement about H_0 or significance it must be compatible. May see CR i.e. $X \leq 4$ (mark when prob seen) and $X \geq 18$ (prob = 0.01406..) Ignore upper limit NB for information $P(X = 4) = 0.0104\dots$ and can only score M1A0A0 if $B(75, 0.14)$ seen		
(e)	B1ft for awrt 0.03 Allow ft of their probability in (d) provided at least 3sf used NB an answer of 0.02 in (d) leading to 0.04 in (e) is B0		
SC	Use of CR will give significance level of $0.01506\dots + 0.01406\dots = 0.029\dots$ score B1 no ft		

Question Number	Scheme	Marks		
<p>3. (a)</p> <p>(b)</p> <p>(c)</p> <p>(d)(i)</p> <p>(ii)</p>	<p>$P(X \leq 7) = 0.8883$ or $P(X \leq 8) = 0.9644$ or $P(X \geq 8) = 0.1117$ or $P(X \geq 9) = 0.0356$ Critical Region is $X \geq 9$ (o.e.)</p> <p>$(1 - 0.9644 =) 0.0356$ [NB Calculator gives: 0.03557486...]</p> <p>Reject H_0/Significant <u>or</u> value of p is > 0.45</p> <p>Conclusion would not change as H_0 would still be rejected</p> <p>Conclusion would change as H_0 would not be rejected</p>	<p>M1</p> <p>A1</p> <p>(2)</p> <p>B1cao</p> <p>(1)</p> <p>B1ft</p> <p>(1)</p> <p>B1</p> <p>B1</p> <p>(2)</p> <p>[6]</p>		
Notes				
<p>(a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p> <p>(i)</p> <p>(ii)</p> <p>CR</p>	<p>M1 for one of these 4 probabilities - may be implied by a correct critical region</p> <p>A1 for $X \geq 9$ (allow $X > 8$) (o.e.) e.g. [9, 12], {9, 10, 11, 12} etc Ans. only 2/2 NB Must be $X \geq 9$ for A1, do not award for just seeing $P(X \geq 9)$</p> <p>B1 for 0.0356 or better</p> <p>B1f ft their critical region in (a) Must say “reject” and “H_0” No contradictory statements Just saying “9 is not in the critical region” is <u>not</u> enough Allow a restart i.e. calculating $P(X \geq 9) = 0.0356 < 0.05$ so significant</p> <p style="text-align: center;">If they score B0 in (c) then score B0B0 in (d)</p> <table border="0" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>In (c) they reject H_0</p> <p>B1 for “No”, “no change”, “significant” etc</p> <p>B1 for “Yes”, “do not reject H_0” etc</p> </td> <td style="width: 50%; vertical-align: top; border-left: 1px solid black; padding-left: 10px;"> <p>In (c) they accept H_0</p> <p>B0 whatever they say</p> <p>B1 for “no change” or “do not reject H_0” etc</p> </td> </tr> </table> <p>(i) NB new CR is $X \geq 9$ but can treat any incorrect mention of CR as ISW</p> <p>(ii) NB new CR is $X \geq 10$ but can treat any incorrect mention of CR as ISW</p>	<p>In (c) they reject H_0</p> <p>B1 for “No”, “no change”, “significant” etc</p> <p>B1 for “Yes”, “do not reject H_0” etc</p>	<p>In (c) they accept H_0</p> <p>B0 whatever they say</p> <p>B1 for “no change” or “do not reject H_0” etc</p>	
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Question Number	Scheme	Marks
<p>5. (a)(i)</p> <p>(ii)</p> <p>(b)</p> <p>(c)</p>	<p>$H_0 : p = 0.35 \quad H_1 : p \neq 0.35$</p> <p>$B(15,0.35)$</p> <p>CR $X \leq 1 \cup X \geq 10$ (Allow any letter)</p> <p>8 is not in CR</p> <p>There is evidence that the Company's <u>claim</u> is true</p> <p>$0.0142 + 0.0124 = 0.0266$</p>	<p>B1</p> <p>M1</p> <p>A1A1</p> <p>(4)</p> <p>M1</p> <p>A1ft</p> <p>(2)</p> <p>B1</p> <p>(1)</p> <p>[7]</p>
Notes		
<p>(a) (i)</p> <p>(ii)</p> <p>(b)</p> <p>(c)</p>	<p>B1 both hypotheses correct. Must mention p (or π). Words only is B0</p> <p>M1 Writing $B(15,0.35)$ May be implied by e.g. $P(X \leq 1) = 0.0142$ or $P(X \leq 9) = 0.9876$</p> <p>1st A1 $X \leq 1$ (accept $X < 2$) Allow $0 \leq X \leq 1$ but $P(X \leq 1)$ is A0</p> <p>2nd A1 $X \geq 10$ (accept $X > 9$) Allow $10 \leq X \leq 15$ but $P(X \geq 10)$ is A0</p> <p>Either correct answer will imply M1</p> <p>M1 for a reason that matches their CR. "Interpret" their CR of $P(X \geq 10)$ as $X \geq 10$ etc</p> <p>Allow calculation of $P(X \geq 8) = 1 - 0.8868 = 0.1132$ and "not sig" comment</p> <p>Do not allow contradictory remarks e.g. 8 is not in CR so significant (this gets M0)</p> <p>A1ft for a conclusion correct for their CR in context</p> <p>Must mention "claim" <u>or</u> "peas" and "germinating"</p> <p>NB A correct contextual claim on its own scores M1A1</p> <p>B1 for 0.0266 or awrt 0.0266 (calc gives 0.02662196...)</p>	

Question Number	Scheme	Marks
2(a)	List of all the customers (who eat in the restaurant)	B1 (1)
(b)	Customer(s) (who ate in the restaurant)	B1 (1)
(c)	Advantage: more/total accuracy, unbiased	B1
	Disadvantage: time consuming to obtain data and analyse it, expensive, difficult to ensure entire population is included	B1 (2)
(d)	Let X = the number of customers who would like more choice on the menu.	
	$H_0: p = 0.3 \quad H_1: p > 0.3$	B1
	$X \sim B(50, 0.3)$	M1
	$P(X \geq 20) = 1 - P(X \leq 19)$ or CR $P(X \leq 20) = 0.9522$	M1
	$= 1 - 0.9152$	$P(X \geq 21) = 0.0478$
	$= 0.0848$	$X \geq 21$
	Do not reject H_0 / not significant/20 is not in critical region	A1
	The percentage of customers who would like more choice on the menu is not more than Bill believes.	M1
	or	
	There is no evidence to reject Bill's belief .	A1cso
		(6)
		Total (10)

Notes

(a)	B1 Need the idea of list/register/database and 'customer(s)'
	Do not allow customer's opinions.
	'All' may be implied. Do not allow a partial list e.g. 'A list of 50 customers'
(b)	B1 customer(s)
	If not labelled, assume the response refers to a census.
(c)	1 st B1 is for the advantage and 2 nd B1 is for the disadvantage.
	B1 need both hypotheses with p
(d)	M1 using $B(50, 0.3)$
	M1 for $1 - P(X \leq 19)$ or
	$P(X \leq 20) = 0.9522$ or $P(X \geq 21) = 0.0478$ leading to a critical region $X > k$ or $X \geq k$
	A1 awrt 0.0848 or critical region $X \geq 21$ or $X > 20$
	M1 a correct conclusion for their probability. May be implied by a correct contextual conclusion.
	A1 a correct contextual conclusion for their hypotheses and a fully correct solution with no errors seen. Must mention 'customers' and 'choice' or 'Bill' and 'belief'.
	NB $P(X=20)$ can score B1M1M0A0M0A0
	NB normal approximation gives 0.082(457...) and loses all A marks

Question Number	Scheme	Marks
2(a)	Only 2 outcomes Heads and Tails oe	
	Constant probability of spinning a Head/Tail oe	
	Coin is spun a fixed number of times oe	
	Each spin of the coin is independent oe	B1 B1
		(2)
(b)	$T \sim B(6, 0.5)$	
	$P(T \leq 5) - P(T \leq 4) = 0.9844 - 0.8906$ or $6\left(\frac{1}{2}\right)^5\left(\frac{1}{2}\right)$ oe	M1
	$= 0.09375$ or $\frac{3}{32}$ oe	awrt 0.0938
		A1
		(2)
(c)	$P(T = 4, 5, 6) = 1 - P(T \leq 3)$	M1
	$= 1 - 0.6563$	
	$= 0.3437$ or $\frac{11}{32}$	awrt 0.344
		A1
		(2)
(d)	$P(H = 3, 4, 5, 6) = 1 - P(H \leq 2)$	B1M1d
	$= 1 - 0.8306$	
	$= 0.1694$ or $\frac{347}{2048}$	awrt 0.169
		A1
		(3)
Notes		Total 9
(a)	B1 A correct statement – does not need to be in context B1 A second correct statement in context include coin or heads or tails(do not allow H and T) or spins/flip oe.	
(b)	M1 [writing or using B(6, 0.5) and writing or using $P(T \leq 5) - P(T \leq 4)$] or $\left[6\left(\frac{1}{2}\right)^6\right]$ oe	
(c)	M1 for realising they need find $P(T = 4, 5 \text{ or } 6)$ eg $1 - P(T \leq 3)$ or $P(T \geq 4)$	
(d)	B1	writing/using B(6, 0.25) and $P(H \geq 3)$ oe
	M1d	dep on B1 for $1 - P(H \leq 2)$
	A1	awrt 0.169
NB	writing/using B(6, 0.75) and $P(T \leq 3)$	
NB	dep on B1 $(0.25)^6 + 6(0.75)(0.25)^5$ $+ 15(0.75)^2(0.25)^4 + 20(0.75)^3(0.25)^3$	
NB	awrt 0.169	
NB	Only accept correct use of H and T in the probability statement unless their variable is correctly defined	
NB	awrt 0.169 with no incorrect working gains B1M1A1	

Question Number	Scheme		Marks
	Allow any letter instead of X or c for this question		
1 (a)	$X \sim B(25, 0.2)$	M1 Writing or using $B(25, 0.2)$ or $B(25, 1/5)$ [allow $Po(5)$] May be written in full or implied by a correct CR (allow written as a probability statement)	M1
	$[P(X \geq 9) =]0.0468$ $[P(X \leq 1) =]0.0274$	1st A1 both awrt 0.0468 and awrt 0.0274 seen.	A1
	$X = [0 \leq] X \leq 1$	2nd A1 $X \leq 1$ or $X < 2$ or $0 \leq X \leq 1$ or $[0, 1]$ or $0, 1$ or equivalent statements. $X \leq c$ and $c = 1$	A1
	$9 \leq X [\leq 25]$	3rd A1d dependent on seeing a probability from the $B(25, 0.2)$ and $X \geq 9$ or $X > 8$ or $9 \leq X \leq 25$ or $9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25$ or $[9, 25]$ or equivalent statements. $X \geq c$ and $c = 9$	A1d
NB These two final 2 A marks must be for statements with “ X ” only (or list) – not in probability statements SC If a probability from the $B(25, 0.2)$ is seen and they either have both CR correct but written as probability statements or the CR is written as $1 \geq X \geq 9$ they get A1 A0 for final 2 marks (4)			
(b)	$H_0: p = 0.2$ $H_1: p < 0.2$	B1 both hypotheses with p or π and clear which is H_0 and which is H_1	B1
	$P(X \leq 6) = 0.1034$ or CR $X \leq 5$	1st M1 writing or using $B(50, 0.2)$ and writing or using $P(X \leq 6)$ or $P(X \geq 7)$ on its own. May be implied by a correct CR	M1
		1st A1 awrt 0.103. Allow CR $X \leq 5$ or $X < 6$. or if not using CR allow awrt 0.897.	A1
	Insufficient evidence to reject H_0 , Accept H_0 , Not significant. 6 does not lie in the Critical region.	2nd M1 dependent on previous M being awarded. A correct statement (do not allow if there are contradicting non-contextual statements). fit their Prob/CR compared with $0.05/6/(0.95$ if using $0.8979)$. Do not follow through their hypotheses	M1d
No evidence that increasing the batch size has reduced the percentage of broken pots (oe) or evidence that there is no change in the percentage of broken pots (oe)	2nd A1cso Conclusion must contain the words reduced/ no change/not affect oe number/percentage/proportion/ probability oe, and pots . All previous marks must be awarded for this mark to be awarded. Do not allow the potters claim /belief is wrong/true NB Correct contextual statement on its own scores M1A1	A1cso	
			(5)
			(Total 9)

Question Number	Scheme		Marks
2(a)		notes	
	$X \sim B(30, 0.25)$	B1: using B(30, 0.25)	B1
	$P(X \leq 10) - P(X \leq 4) = 0.8943 - 0.0979$	M1: using $P(X \leq 10) - P(X \leq 4)$ or $P(X \geq 5) - P(X \geq 11)$ oe	M1 A1
	$= 0.7964$	A1: awrt 0.796	
NB a correct answer gains full marks			

(b)	$H_0 : p = 0.25$ $H_1 : p < 0.25$	B1: Both hypotheses correct, labelled H_0 or NH or H_n and H_1 or AH or H_a , must use p or $p(x)$ or π	B1	
	B(15, 0.25)	M1: for using B(15, 0.25)	M1 A1	
	$P(X \leq 1) = 0.0802$	A1: awrt 0.0802 or CR $X \leq 1$ (allow $P(X \geq 2) = 0.9198$)		
	NB: Allow M1 A1 for a correct CR with no incorrect working			
Reject H_0 or Significant or 1 lies in the critical region	M1: A correct statement – do not allow contradictory non contextual statements. Follow through their Probability/CR (for 1 or 2 tail test). If no H_1 given then M0. Ignore their comparison. For a probability < 0.5 , statement must be correct compared to 0.1 for 1 tail test and 0.05 for 2 tailed test or if the probability > 0.5 , statement must be correct compared to 0.9 for 1 tail test and 0.95 for 2 tailed test.	dM1 A1cso		
There is evidence that the radio company's claim is true. Or The new transmitter will reduce the proportion of houses unable to receive radio	A1: cso (all previous marks awarded) and a correct statement containing the word company if writing about the claim or radio if full context.			