

Mark Scheme

Q1.

Question Number	Scheme	Marks
(a)	$X \sim B(20, 0.25)$ $P(X \geq 10) = 1 - 0.9861 = 0.0139$ $P(X \leq 1) = 0.0243$ $(0 \leq) X \leq 1 \cup 10 \leq X (\leq 20)$	M1 A1 A1 A1A1 (5)
(b)	$H_0: p = 0.25$ $H_1: p < 0.25$ $X \sim B(20, 0.25)$ $P(X \leq 3) = 0.2252$ or CR $X \leq 1$ Insufficient evidence to reject H_0 . Accept H_0 . Not significant. 3 does not lie in the Critical region. No evidence that the changes to the process have reduced the percentage of defective articles (oe)	B1 M1A1 M1d A1cso (5) Total 10 marks
Notes		
(a)	M1 using $B(20, 0.25)$ may be implied by a correct CR (allow written as a probability statement) 1 st A1 awrt 0.0139 2 nd A1 awrt 0.0243 3 rd A1 $X \leq 1$ or $0 \leq X \leq 1$ or $[0, 1]$ or 0,1 or equivalent statements 4 th A1 $X \geq 10$ or $10 \leq X \leq 20$ or 10,11,12,13,14,15,16,17,18,19,20 or $[10, 20]$ or equivalent statements NB These two A marks must be for statements with X (any letter) only – not in probability statements and SC for CR written as $1 \geq X \geq 10$ gets A1 A0	
(b)	B1 both hypotheses with p 1 st M1 using $B(20, 0.25)$ and finding $P(X \leq 3)$ or $P(X \geq 4)$ may be implied by a correct CR 1 st A1 0.2252 (allow 0.7748) if not using CR or CR $X \leq 1$ or $X < 2$ 2 nd M1 dependent on previous M being awarded. A correct statement (do not allow if there are contradicting non contextual statements) A1cso Conclusion must contain the words changes/new process oe, reduced oe number/percentage oe , and defective articles/defectives . There must be no incorrect working seen.	

Q2.

Question Number	Scheme		Marks
	Allow any letter instead of X or c for this question		
(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). ft 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)

Q3.

Question Number	Scheme		Marks
(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)	$H_0 : p = 0.25 \quad H_1 : p < 0.25$	B1: Both hypotheses correct, labelled H_0 or NH or H_a 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 <u>company's</u> claim is true. Or The new transmitter will reduce the proportion of houses unable to receive <u>radio</u>	A1: cso (all previous marks awarded) and a correct statement containing the word <u>company</u> if writing about the claim or <u>radio</u> if full context.	

Q4.

Question Number	Scheme	Marks
(a)	$X \sim B(15, 0.5)$	B1 B1 (2)
(b)	$P(X=8) = P(X \leq 8) - P(X \leq 7) \quad \text{or} \quad \left(\frac{15!}{8!7!} (p)^8 (1-p)^7 \right)$ $= 0.6964 - 0.5$ $= 0.1964$	M1 A1 (2)
(c)	$P(X \geq 4) = 1 - P(X \leq 3)$ $= 1 - 0.0176$ $= 0.9824$	M1 A1 (2)
(d)	$H_0 : p = 0.5$ $H_1 : p > 0.5$ $X \sim B(15, 0.5)$ $P(X \geq 13) = 1 - P(X \leq 12)$ $= 1 - 0.9963$ $= 0.0037$	B1 B1
	$0.0037 < 0.01$	M1 A1
	$13 \geq 13$	
	Reject H_0 or it is significant or a correct statement in context from their values	M1
	There is sufficient evidence at the 1% significance level that the coin is <u>biased in favour of heads</u> or There is evidence that Sue's belief is correct	A1 (6)
		(12 marks)

Q5.

Question Number	Scheme	Marks
	<u>One tail test</u> <u>Method 1</u> $H_0 : p = 0.2$ $H_1 : p > 0.2$ $X \sim B(5, 0.2)$ may be implied $P(X \geq 3) = 1 - P(X \leq 2)$ $[P(X \geq 3) = 1 - 0.9421 = 0.0579]$ att $P(X \geq 3)$ $P(X \geq 4)$ $\quad = 1 - 0.9421$ $P(X \geq 4) = 1 - 0.9933 = 0.0067$ $\quad = 0.0579$ CR $X \geq 4$ awrt 0.0579 $0.0579 > 0.05$ $3 \leq 4$ or 3 is not in critical region or 3 is not significant (Do not reject H_0 .) There is insufficient evidence at the 5% significance level that there is an increase in the number of times <u>the taxi/driver is late</u> . Or Linda's claim is not justified	B1 B1 M1 M1 A1 M1 B1 (7) (Total 7)
	<u>Method 2</u> $H_0 : p = 0.2$ $H_1 : p > 0.2$ $X \sim B(5, 0.2)$ may be implied $P(X < 3) =$ $[P(X < 3) = 0.9421]$ att $P(X < 3)$ $P(X < 4)$ $\quad \quad \quad P(X < 4) = 0.9933$ $\quad \quad \quad 0.9421$ CR $X \geq 4$ awrt 0.942 $0.9421 < 0.95$ $3 \leq 4$ or 3 is not in critical region or 3 is not significant (Do not reject H_0 .) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the <u>taxi/driver is late</u> . Or Linda's claim is not justified	B1 B1 M1 M1A1 M1 B1 (7)

Two tail testMethod 1

$$H_0 : p = 0.2$$

$$H_1 : p \neq 0.2$$

$$X \sim B(5, 0.2)$$

may be implied

$$P(X \geq 3) = 1 - P(X \leq 2) \\ = 1 - 0.9421$$

$$[P(X \geq 3) = 1 - 0.9421 = 0.0579] \\ P(X \geq 4) = 1 - 0.9933 = 0.0067$$

att $P(X \geq 3)$ $P(X \geq 4)$

$$= 0.0579$$

$$CR X \geq 4$$

awrt 0.0579

$$0.0579 > 0.025$$

 $3 \leq 4$ or 3 is not in critical region or 3 is not significant

(Do not reject H_0 .) There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late.

Or Linda's claim is not justified

Method 2

$$H_0 : p = 0.2$$

$$H_1 : p \neq 0.2$$

$$X \sim B(5, 0.2)$$

may be implied

$$P(X < 3) =$$

$$[P(X < 3) = 0.9421] \\ P(X < 4) = 0.9933$$

att $P(X < 3)$ $P(X < 4)$

$$0.9421$$

$$CR X \geq 4$$

awrt 0.942

$$0.9421 < 0.975$$

 $3 \leq 4$ or 3 is not in critical region or 3 is not significant

Do not reject H_0 . There is insufficient evidence at the 5% significance level that there is an increase in the number of times the taxi/driver is late.

Or Linda's claim is not justified

Special Case

If they use a probability of $\frac{1}{7}$ throughout the question they may gain B1 B1 M0 M1

A0 M1 B1.

NB they must attempt to work out the probabilities using $\frac{1}{7}$

B1

B0

M1

M1

A1

M1

B1

(7)

B1

B0

M1

M1A1

M1

B1

(7)

Q6.

Question	Scheme	Marks
	$H_0 : p = 0.2$ $H_1 : p < 0.2$ $[X \sim B(40, 0.2)]$ $P(X \leq 3) = 0.0285$ or CR of $X \leq 3$ $[0.0285 < 0.05]$ significant, reject H_0 There is evidence to support the supplier's <u>claim</u> or The probability of a <u>ball</u> failing the bounce <u>test</u> is <u>less</u> than <u>0.2</u>	B1 M1A1 M1dep A1eso (5)
	Notes	
	1 st B1 for both H_0 and H_1 must use p or π 1 st M1 for writing or using $B(40, 0.2)$, may be implied by correct answer 1 st A1 awrt 0.0285 or CR of $X \leq 3$ as their final answer 2 nd M1 dependent on the previous method mark being awarded. A correct statement (this may be contextual) comparing "their probability" and 0.05 (or comparing 3 with their critical region). Do not allow conflicting statements. 2 nd A1eso This is eso so can only be awarded for a fully correct solution. A correct contextualised conclusion (to include the words underlined in bold)	

Q7.

Question Number	Scheme	Marks
(a)	2 outcomes/faulty or not faulty/success or fail A constant probability Independence Fixed number of trials (fixed n)	B1 B1 (2)
(b)	$X \sim B(50, 0.25)$ $P(X \leq 6) = 0.0194$ $P(X \leq 7) = 0.0453$ $P(X \geq 18) = 0.0551$ $P(X \geq 19) = 0.0287$ CR $X \leq 6$ and $X \geq 19$	M1 A1 A1 (3)
(c)	$0.0194 + 0.0287 = 0.0481$	M1A1 (2)
(d)	8(It) is not in the Critical region or 8(It) is not significant or $0.0916 > 0.025$; There is evidence that the probability of a faulty bolt is 0.25 or the company's claim is correct.	M1; A1ft (2)
(e)	$H_0: p = 0.25$ $H_1: p < 0.25$ $P(X \leq 5) = 0.0070$ or CR $X \leq 5$ $0.007 < 0.01$, 5 is in the critical region, reject H_0 , significant. There is evidence that the probability of faulty bolts has decreased	B1B1 M1A1 M1 A1ft (6) [15]
Notes		
(a)	B1 B1 one mark for each of any of the four statements. Give first B1 if only one correct statement given. No context needed.	
(b)	M1 for writing or using $B(50, 0.25)$ also may be implied by both CR being correct. Condone use of P in critical region for the method mark. A1 $(X) \leq 6$ o.e. $[0, 6]$ DO NOT accept $P(X \leq 6)$ A1 $(X) \geq 19$ o.e. $[19, 50]$ DO NOT accept $P(X \geq 19)$	
(c)	M1 Adding two probabilities for two tails. Both probabilities must be less than 0.5 A1 awrt 0.0481	
(d)	M1 one of the given statements followed through from their CR. A1 contextual comment followed through from their CR. NB A correct contextual comment <u>alone</u> followed through from their CR will get M1 A1	
(e)	B1 for H_0 must use p or π (pi) B1 for H_1 must use p or π (pi) M1 for finding or writing $P(X \leq 5)$ or attempting to find a critical region or a correct critical region A1 awrt 0.007/CR $X \leq 5$ M1 correct statement using their Probability and 0.01 if one tail test or a correct statement using their Probability and 0.005 if two tail test. The 0.01 or 0.005 needn't be explicitly seen but implied by correct statement compatible with their H_1 . If no H_1 given M0 A1 correct contextual statement follow through from their prob and H_1 . Need faulty bolts and decreased. NB A correct contextual statement <u>alone</u> followed through from their prob and H_1 get M1 A1	

Q8.

Question Number	Marks	Scheme
	$H_0 : p = 0.3; H_1 : p > 0.3$ Let X represent the number of tomatoes greater than 4 cm : $X \sim B(40, 0.3)$ $P(X \geq 18) = 1 - P(X \leq 17)$ $= 0.0320$ $0.0320 < 0.05$ no evidence to Reject H_0 or it is significant New fertiliser has <u>increased</u> the probability of a <u>tomato</u> being greater than 4 cm Or Dhriti's claim is true	B1 B1 B1 M1 A1 M1 B1d cao (7)

B1 for correct H_0. must use p or pi B1 for correct H_1 must use p and be one tail. B1 using $B(40, 0.3)$. This may be implied by their calculation M1 attempt to find $1 - P(X \leq 17)$ or get a correct probability. For CR method must attempt to find $P(X \geq 18)$ or give the correct critical region A1 awrt 0.032 or correct CR. M1 correct statement based on their probability, H_1 and 0.05 or a correct contextualised statement that implies that. B1 this is not a follow through conclusion in context. Must use the words increased, tomato and some reference to size or diameter. This is dependent on them getting the previous M1 If they do a two tail test they may get B1 B0 B1 M1 A1 M1 B0 For the second M1 they must have accept H_0 or it is not significant or a correct contextualised statement that implies that.	
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Q9.

Question Number	Scheme	Marks
(a)	The set of values of the test statistic for which the null hypothesis is rejected in a hypothesis test.	B1 B1 (2)
(b)	$X \sim B(30, 0.3)$ $P(X \leq 3) = 0.0093$ $P(X \leq 2) = 0.0021$ $P(X \geq 16) = 1 - 0.9936 = 0.0064$ $P(X \geq 17) = 1 - 0.9979 = 0.0021$ Critical region is $(0 \leq) x \leq 2$ or $16 \leq x (\leq 30)$	M1 A1 A1 A1A1 (5)
(c)	Actual significance level $0.0021 + 0.0064 = 0.0085$ or 0.85%	B1 (1)
(d)	15 (it) is not in the critical region not significant No significant evidence of a change in $p = 0.3$ accept H_0 , (reject H_1) $P(x \geq 15) = 0.0169$	Bft 2, 1, 0 (2)
		Total [10]
	Notes (a) 1 st B1 for "values/ numbers" 2 nd B1 for "reject the null hypothesis" o.e or the test is significant (b) M1 for using $B(30, 0.3)$ 1 st A1 $P(x \leq 2) = 0.0021$ 2 nd A1 0.0064 3 rd A1 for $(X) \leq 2$ or $(X) < 3$ They get A0 if they write $P(X \leq 2 / X < 3)$ 4 th A1 $(X) \geq 16$ or $(X) > 15$ They get A0 if they write $P(X \geq 16 / X > 15)$ NB these are B1 B1 but mark as A1 A1 16 $\leq$ $X \leq 2$ etc is accepted To describe the critical regions they can use any letter or no letter at all. It does not have to be X . (c) B1 correct answer only (d) Follow through 15 and their critical region B1 for any one of the 5 correct statements up to a maximum of B2 – B1 for any incorrect statements	

Q10.

Qu	Scheme	Marks	AO
(a)	$H_0 : p = 0.1$ $H_1 : p \neq 0.1$ [Allow 10% for 0.1] $[X \sim B(40, 0.1)] \Rightarrow P(X = 0) = 0.0148$ [Allow any letter for X] $P(X \dots 9) = 1 - P(X \leq 8) = 1 - 0.9845 = 0.0155$ Critical region is $\{X = 0\} \cup \{X \dots 9\}$ (o.e.)	B1 M1 A1 A1	2.5 3.3 1.1b 1.1b
(b)	[“0.0148” + “0.0155”] = 0.0303	B1ft (4) (1)	1.1b
(c)	[Provided 7 is not in their CR] insufficient evidence to support Freya’s belief	B1 (1)	2.2b
(6 marks)			
Notes			
(a)	Mark (a) and (b) together for sight of the probabilities. B1 for both hypotheses in terms of p or π. Must be attached to H_0 and H_1 M1 for <u>use</u> of the correct model. Implied by sight of at least one probability truncated or rounded to at least 2sf from: 0.0155, 0.0148, 0.0805, 0.9845, 0.9581, 0.9949 Implied by sight of fully correct CR (with no probs) so e.g. $X = 0, X > 8$ scores M1A0A0 1st A1 for at least one correct probability (to at least 3sf) with its probability statement i.e. for $P(X = 0) = \text{awrt } 0.0148$ <u>or</u> $P(X \dots 9) = \text{awrt } 0.0155$ 2nd A1 (dep on M1 and 1st A1 but not on B1) for both correct probs (to at least 3 sf) <u>and</u> the correct critical region Do not need set notation. Allow $X < 1$ and $X > 8$ <u>or</u> words e.g. “0 or greater than 8” etc Allow “,” <u>or</u> “and” <u>or</u> “or” <u>or</u> “$\cap$” between $X \leq 0$ and $X \dots 9$ $P(X = 0)$ and $P(X \dots 9)$ is 2nd A0		
(b)	B1ft for awrt 3.03% <u>or</u> correct sum of their two probabilities (provided each is less than 0.5) Their probabilities must be to at least 2sf and relate to their CR To score in (c) they must have a CR of the form $(X = 0 \text{ or } X < a) \text{ and } X > b$, where b is ...7 May be implied by $P(X < a)$ and $P(X > b)$ i.e. 2nd A0 in (a) but correct form. Need $b > a$		
(c)	B1 for a suitable comment in context that suggests <u>no support</u> for Freya’s <u>belief/claim</u> or e.g. <u>insufficient</u> evidence of change in <u>proportion/percentage</u> of <u>left-handed</u> adults or e.g. <u>proportion/percentage</u> of <u>left-handed</u> adults is <u>not different</u> from 10% (or ...is 10%) or e.g. <u>10%</u> of adults in the country are <u>left-handed</u> Do not allow contradictory comments e.g. “in CR so no support for Freya’s belief” is B0		
NB	A correct contextual answer in (c) using an acceptance region please send to review.		