	Question		Answer	Marks		Guidance
1	(i)	(A)	$X \sim B(10, 0.35)$ P(5 accessing internet) $= \dbinom{10}{5} \times 0.35^5 \times 0.65^5$	M1 M1	or $0.35^5 \times 0.65^5$ For $\dbinom{10}{5} \times p^5 \times q^5$	With $p + q = 1$ Also for 252×0.0006094
			$= 0.1536$	A1	cao	Allow 0.15 or better <u>NB 0.153 gets A0</u> See tables at the website <u>http://www.mei.org.uk/files/pdf/formula_book_mf2.pdf</u>
			OR from tables $= 0.9051 - 0.7515 = 0.1536$	**OR** M2 A1 **[3]**	For $0.9051 - 0.7515$ cao	
	(i)	(B)	P $X \geq 5) = 1 - P(X \leq 4)$ $= 1 - 0.7515$ $= 0.2485$	M1 A1 **[2]**	For 0.7515 cao	Accept 0**.**25 or better – allow 0.248 or 0.249 Calculation of individual probabilities gets B2 if fully correct 0.25 or better, otherwise B0.
	(i)	(C)	E(X) = $np = 10 \times 0.35$ $= 3.5$	M1 A1 **[2]**	For 10×0.35 cao	If any indication of rounding to 3 or 4 allow M1A0

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1	(ii)		Let $X \sim B(20, 0.35)$ Let p = probability of a customer using the internet (for population)	B1	For definition of p in context	Minimum needed for B1 is p = probability of using internet. Allow p = P(using internet) Definition of p must include word probability (or chance or proportion or percentage or likelihood but NOT possibility). Preferably as a separate comment. However can be at end of H_0 as long as it is a clear definition 'p = the probability of using internet', Do NOT allow 'p = the probability of using internet is different'
			H_0: $p = 0.35$	B1	Fo H_0	Allow p=35%, allow only p or θ or π or ρ. However allow any single symbol <u>if defined</u> (including x) Allow $H_0 = p=0.35$, Allow H_0: $p={}^7/_{20}$ or $p={}^{35}/_{100}$ Allow NH and AH in place of H_0 and H_1 Do not allow H_0 : P($X=x$) = 0.35 Do not allow H_0: =0.35, =35%, P(0.35), p(x)=0.35, x=0.35 (unless x correctly defined as a probability) Do not allow H_0 and H_1 reversed For hypotheses given in words allow Maximum B0B1B1 Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.35 oe Thus eg H_0 : p(using internet) = 0.35, H_1 : p(using internet) $\neq$ 0.35 gets B0B1B1

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	H_1: $p \neq 0.35$	B1	Fo H_1	Allow '$p < 0.35$ or $p > 0.35$'in place of $p \neq 0.35$	
	H_1 has this form because the test is to investigate whether the proportion is different, (rather than lower or higher).	E1		Do not allow if H_1 wrong.	
	$P(X \geq 10)$	B1	Fo notation $P(X \geq 10)$ or $P(X > 9)$ or $1 - P(X \leq 9)$ (as long as no incorrect notation)	This mark may be implied by 0.1218 as long as no incorrect notation. No further marks if point probs used - $P(X = 10) = 0.0686$ (do not even give the notation mark for correct notation) DO NOT FT wrong H_1, but see extra notes	
	$= 1 - 0.8782 = 0.1218$	B1*	For 0.1218 Allow 0.12	Or for $1 - 0.8782$ Indep of previous mark	
	> 2.5	M1* dep	For comparison with 2.5%		
	So not significant. Conclude that there is not enough evidence to indicate that the probability is different. (Must state 'probability', not just 'p')	A1* E1* dep on A1		Allow 'accept H_0' or 'reject H_1' Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark.	
	ALTERNATIVE METHOD FOR FINAL 5 MARKS				
	Critical region method LOWER TAIL $P(X \leq 2) = 0.0121 < 2.5\%$ $P(X \leq 3) = 0.0444 > 2.5\%$	B1	For either probability	Do not insist on correct notation as candidates have to work out two probabilities for full marks. If only upper tail of CR given (or only upper tail justified), allow max 4/5 for final 5 marks.	
	UPPER TAIL $P(X \geq 11) = 1 - P(X \leq 10) = 1 - 0.9468 = 0.0532 > 2.5\%$ $P(X \geq 12) = 1 - P(X \leq 11) = 1 - 0.9804 = 0.0196 < 2.5\%$	B1	For either probability		

Question			Answer	Marks		Guidance
			So critical region is {0,1,2,12,13,14,15,16,17,18,19,20}	M1* dep	cao dep on at least one correct comparison with 2.5%	No marks if CR not justified Condone {0,1,2, 12, … 20}, $X \leq 2$, $X \geq 12$, oe but not P($X \leq 2$) etc
			So not significant Conclude that there is not enough evidence to indicate that the probability is different.	A1* E1* dep on A1		NB If CR found correctly then P($X = 10$) subsequently found but cand says '10 not in CR' then allow up to all last five marks. If do not say '10 not in CR' allow none of last five marks
				[9]		
1	(iii)		0.0022 < 2.5% So reject H$_o$, Significant.	B1	For either reject H$_o$ or significant, dep on correct comparison	
			Conclude that there is enough evidence to indicate that the probability is different.	E1* dep	Dep on good attempt at correct hypotheses in part (ii)	If they have H$_1$: p>0.35, allow SC1 if all correct including comparison with 5%.
				[2]		

Question			Answer	Marks	Guidance
2			Let p = probability that a randomly selected frame is faulty	B1	For definition of p in context Minimum needed for B1 is p = probability that frame/bike is faulty. Do not allow is p = probability that it is faulty Allow p = P(frame faulty) Definition of p must include word probability (or chance or proportion or percentage or likelihood but NOT possibility). Preferably as a separate comment. However can be at end of H_0 as long as it is a clear definition ' p = the probability that frame is faulty, NOT just a sentence 'probability is 0.05' Do NOT allow 'p = the probability that faulty frames have increased'
			H_0: $p = 0.05$	B1	H_0 : p(frame faulty) = 0.05, H_1 : p(frame faulty) > 0.05 gets B0B1B1 Allow p=5%, allow θ or π and ρ but not x. However allow any single symbol <u>if defined</u> Allow $H_0 = p$=0.05, Allow H_0 : p=$^1/_{20}$ Do not allow H_0 : P(X=x) = 0.05, H_1 : P(X=x) > 0.05 Do not allow H_0: =0.05, =5%, P(0.05), p(0052), p(x)=0.05, x=0.05 (unless x correctly defined as a probability) Do not allow H_1:p≥0.05, Do not allow H_0 and H_1 reversed Allow NH and AH in place of H_0 and H_1 For hypotheses given in words allow Maximum B0B1B1 Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.05 oe.
			H_1: $p > 0.05$	B1	
			P($X \geq 4$)	B1	For notation P($X \geq 4$) or 1- $X \leq 3$) This mark may be implied by 0.0109 as long as no incorrect notation. / No further marks if point probs used - P($X = 4$) = 0.0094 DO NOT FT wrong H_1 But if H_1 is $p \geq 0.05$ allow the rest of the marks if earned so max 7/8
			= 1- P($X \leq 3$) = 1 – 0.9891 = 0.0109	B1*	For 0.0109, indep of previous mark / Or for 1 – 0.9891

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Question	Answer	Marks	Guidance
	$0.0109 < 0.05$	M1* dep	For comparison with 5%
	So reject H_0	A1*	or significant or 'accept H_1'
	There is evidence to suggest that the proportion of faulty frames has increased.	E1* Dep on A1	Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt for E1. 'Sufficient evidence' or similar can be seen in the either the A mark or the E mark.
		[8]	
	OR *Critical region method:* Let $X \sim B(18, 0.05)$ $P(X \geq 3) = 1 - P(X \leq 2) = 1 - 0.9419 = 0.0581 > 5\%$	(B1)	For 0.0581 — No marks if CR not justified. Do not insist on correct notation as candidates have to work out two probabilities for full marks
	$P(X \geq 4) = 1 - P(X \leq 3) = 1 - 0.9891 = 0.0109 < 5\%$	(B1)	For 0.0109
		(M1)	For at least one correct comparison with 5%
	So critical region is {4,5,6,7,8,9,10,11,12,13,14,15,16,17,18}	(A1)	CAO for critical region and significant oe — Condone {4,5 ..}, $X \geq 4$, oe but not $P(X \geq 4)$
	4 lies in the critical region, so significant,		
	There is evidence to suggest that the proportion of faulty frames has increased.	(E1)	

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3	(i)	(A)	X ~ B(20, 0.25) $P(4 \text{ smokers}) = \binom{20}{4} \times 0.25^4 \times 0.75^{16} = 0.1897$ **OR** Or from tables = 0.4148 – 0.2252 = 0.1896	M1 M1 A1 M2 A1 **[3]**	For $0.25^4 \times 0.75^{16}$ For $\binom{20}{4} \times p^4 \times q^{16}$ CAO For 0.4148 – 0.2252 CAO	With $p + q = 1$ Also for 4845×0.00003915 Allow 0.19 or better See tables at the website http://www.mei.org.uk/files/pdf/formula_book_mf2.pdf **0.189 gets A0**
	(i)	(B)	$P(3 \le X \le 6) = 0.7858 – 0.0913 = 0.6945$	M1 M1 A1 **[3]**	For (P($X\le6$) =) 0.7858 seen For **their** 0.7858 – 0.0913 CAO	Or P(X=3) + P(X=4) + P(X=5) + P(X=6) = 0.1339 + 0.1897 + 0.2023 + 0.1686 = 0.6945. M1 for three correct terms (to 2sf). Accept 0.69 or better **P($X\ge3$) - P(X>6) = 0.9087-0.2142 = 0.6945 Gets M1 M1 A1**

Question			Answer	Marks	Guidance	Additional Guidance
3	(i)	(*C*)	$E(X) = np = 20 \times 0.25 = 5$	B1 **[1]**	CAO	
	(ii)	(*A*)	Let p = probability that a randomly selected student is a smoker H_0: $p = 0.25$ H_1: $p < 0.25$	B1 B1 B1 **[3]**	For definition of p in context For H_0 For H_1 **Allow complementary probabilities. Mark as per scheme.** **ie H_0:p = 0.75 etc**	Minimum needed for B1 is p = probability that student is a smoker. Allow p = P(student smokes) for B1 Definition of p must include word probability (or chance or proportion or percentage or likelihood but NOT possibility). Preferably as a separate comment. However can be at end of H_0 as long as it is a clear definition ' p = the probability that student is a smoker.,NOT just a sentence 'probability is 0.25' H_0 : p(student is a smoker) = 0.25, H_1 : p(student is a smoker) < 0.25 gets B0B1B1 Allow p=25%, allow θ or π and ρ but not *x*. However allow any single symbol if defined Allow H_0 = p=0.25, Do not allow H_0 : P(*X*=*x*) = 0.25, H_1 : P(*X*=*x*) < 0.25 Do not allow H_0: =0.25, =25%, P(0.25), p(0.25), p(*x*)=0.25, *x*=0.25 (unless *x* correctly defined as a probability) Do not allow H_1:p≤0.25, Do not allow H_0 and H_1 reversed for B marks but can still get E1 below Allow NH and AH in place of H_0 and H_1 For hypotheses given in words allow Maximum B0B1B1 and E1 below. Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.25 oe.

	Question		Answer	Marks	Guidance	Additional Guidance
3	(ii)	(*B*)	H$_1$ has this form as the programme aims to reduce the **proportion** of smokers.	E1 **[1]**	**Allow 'number'** **Allow 'aims for a reduction' or similar**	E0 if H$_1$ **upper tail or two tailed**
	(iii)		P($X \le 1$) = 0.0243 < 5% P($X \le 2$) = 0.0913 > 5% So critical region is {0,1}	B1 B1 M1 A1 **[4]**	For **P($X \le 1$) =** 0.0243 For **P($X \le 2$) =** 0.0913 For at least one comparison with 5% CAO for critical region *dep* on M1 and at least one B1	**With full correct notation.** **Penalise once for eg P(X=1), P(X=2)** Allow any form of statement of CR eg $X \le$ 1, $X <$ 2, annotated number line, etc but not P($X \le 1$) NB USE OF POINT PROBABILITIES gets B0B0M0A0 If no working but correct CR, no marks See additional notes below the scheme for other possibilities
	(iv)		3 does not lie in the critical region, so not significant, So there is not enough evidence to reject the null hypothesis and we conclude that there is not enough evidence to suggest that the percentage of smokers has decreased.	E1**dep** E1**dep** **[2]**	For 3 not in CR or for not significant **or reject H$_1$** For conclusion in context **Condone omission of 'not enough evidence' in this case**	Dep on correct CR, (**correctly obtained**) E0E0 for P(X=3) not in CR **E0E0 if wrong working after 3 not in CR** Alternative scheme P($X \le 3$) = 0.2252 > 5% so not sig etc. gets E2 for complete method but E0 otherwise.