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Question			Answer	Marks		Guidance
1	(i)		$P(\text{All blue}) = \frac{30}{50} \times \frac{29}{49} \times \frac{28}{48} = 0.2071$	M1	For $\frac{30}{50} \times$ (as part of a triple product)	$\frac{}{50}$ other … Zero fo… simplifi…
				M1	For product of other two fractions	Correct … multipli… factor s…
			OR $\binom{30}{3} / \binom{50}{3} = 4060/19600 = 29/140 = 0.2071$	A1	CAO	Accept … 0.207 w…
			M2 for the complete method	[3]	SC2 for P(All red) = 0.0582	Allow u… final an…
1	(ii)		$P(\text{All red}) = \frac{20}{50} \times \frac{19}{49} \times \frac{18}{48} = 0.0582$ or $\binom{20}{3} / \binom{50}{3} = 0.0582$	M1	For P(All red)	SC2 for … = 1 – 0.… providi… not cons…
			P(At least one of each colour) = 1 – (0.2071 + 0.0582) = 0.7347 or $1 - \left(\frac{29}{140} + \frac{57}{980}\right) = 1 - \frac{260}{980} = 1 - \frac{13}{49} = \frac{36}{49}$	M1	For 1 – (0.2071 + 0.0582)	
				A1	CAO	Allow …
			OR	[3]		Allow u… final an…
			P(2b,1r)+P(1b,2r)	(M1)	For either $\frac{30}{50} \times \frac{29}{49} \times \frac{20}{48}$ or $\frac{20}{50} \times \frac{19}{49} \times \frac{30}{48}$	Allow M… 3×(30/5… 3×(30/5… M1 for … If not c… M0M0A…

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Question			Answer	Marks		ance
			$= 3\times\frac{30}{50}\times\frac{29}{49}\times\frac{20}{48}+3\times\frac{20}{50}\times\frac{19}{49}\times\frac{30}{48}$	(M1)	For sum of both or for 3 either	42
			$= 3 \times 0.1480 + 3 \times 0.0969 = 0.7347$	(A1)	CAO	5(even Allow working
			OR Either $\binom{30}{2}\times\binom{20}{1}/\binom{50}{3}$ or $\binom{30}{1}\times\binom{20}{2}/\binom{50}{3}$	(M1)		
				(M1) (A1)	For sum of both CAO	
2	**(i)**		$^9C_3 \times {}^5C_3 = 84 \times 10 = 840$	M1 M1	For either $^9C_3$ or $^5C_3$ For product of both correct combinations	Zero fo
				A1 **[3]**	CAO	
2	**(ii)**		Total number of ways of answering 6 from 14 is $^{14}C_6 = 3003$ Probability $=\frac{840}{3003}=\frac{40}{143}=0.27972=0.280$	M1 M1	For $^{14}C_6$ seen in part (ii) For their 840/ 3003 or their 840/ $^{14}C_6$	
				A1 **[3]**	FT their 840	Allow f unsimpl
			OR $^6C_3 \times 5/14 \times 4/13 \times 3/12 \times 9/11 \times 8/10 \times 7/9 = 0.280$	(M1)	For product of fractions	SC1 for 0.2420
				(M1) (A1)	For $^6C_3\times$ correct product	

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Question			Answer	Marks		ance
3	(i)		X ~ B(30, 0.85) $P(X = 29) = \binom{30}{29} \times 0.85^{29} \times 0.15^{1} = 30 \times 0.0013466 = 0.0404$	M1 M1 A1 **[3]**	For $0.85^{29} \times 0.15^{1} = 0.0013466$ For $\binom{30}{29} \times p^{29} \times q^{1}$ CAO	Allow 0 If furthe $-P(X=2$
3	(ii)		$P(X = 30) = 0.85^{30} = 0.0076$ $P(X \geq 29) = 0.0404 + 0.0076 = 0.0480$	M1 M1 A1 **[3]**	For 0.85^{30} For P(X = 29) + P(X = 30) (not necessarily correct, but both attempts at binomial, including coefficient in (i)) CAO	Allow e Allow 0
3	(iii)		Expected number = 10 × 0.0480 = 0.480	M1 A1 **[2]**	For 10 × their **(ii)** FT their **(ii)** but if answer to (ii) leads to a whole number for (iii) give M1A0	**provide** Do not 0 or 1.

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Question			Answer	Marks		Guidance
4	(i)	(A)	P(third selected) = $0.92^2 \times 0.08 = 0.0677$ Or = 1058/15625	M1 M1 A1 [3]	For 0.92^2 For $p^2 \times q$ CAO	An 0.07 SC1 for 'without replacement' meth =0.0690
4	(i)	(B)	P (second) + P(third) $= (0.92 \times 0.08) + (0.92^2 \times 0.08)$ $= 0.0736 + 0.0677 = 0.1413$ = 2208/15625	M1 A1 [2]	For 0.92×0.08 FT their 0.0677 SC1 for answer of 0.143 from 'witho	With no Allow 0 allow 0.
4	(ii)		P(At least one of first 20) = 1 - P(None of first 20) $= 1 - 0.92^{20} = 1 - 0.1887 = 0.8113$	M1 M1 A1 [3]	0.92^{20} $1 - 0.92^{20}$ CAO	Accept from P(all corre wrong a No mar replacer Allow 0 not 0.81

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Question			Answer	Marks		
5			Let p = probability that a randomly selected frame is faulty	B1	For definition of p in co Minimum needed for B1 is faulty. Do not allow is p = p Allow p = P(frame faulty) Definition of p must include word p proportion or percentage or likelihoo Preferably as a separate comment. H H_0 as long as it is a clear definition ' frame is faulty, NOT just a sentence Do NOT allow 'p = the probability t increased'	
			H_0: $p = 0.05$	B1	H_0 : p(frame faulty) = 0.05, H_1 : p(fra B0B1B1 Allow p=5%, allow θ or π and ρ but any single symbol if defined Allow $H_0 = p$=0.05, Allow H_0 : p=1/ Do not allow H_0: P(X=x) = 0.05, H_1 Do not allow H_0: =0.05, =5%, P(0.0 x=0.05 (unless x correctly defined as 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 an For hypotheses given in words allow Hypotheses in words must include p proportion or percentage) and the fig	
			H_1: $p > 0.05$	B1		
			P($X \geq 4$)	B1	For notation P($X \geq 4$) or 1- P($X \leq 3$) This mark may be implied by 0.0109 as long as no incorrect notation.	No furth used - P DO NO But if H rest of t max 7/8
			= 1- P($X \leq 3$) = 1 – 0.9891 = 0.0109	B1*	For 0.0109, indep of previous mark	Or for 1

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Question	Answer	Marks		ance
	$0.0109 < 0.05$	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' as 'to suggest that' ie an element of evidence' or similar can be seen in the E mark.	
		[8]		
	OR *Critical region method:*			No mar
	Let $X \sim B(18, 0.05)$			Do not
	$P(X \geq 3) = 1 - P(X \leq 2) = 1 - 0.9419 = 0.0581 > 5\%$	(B1)	For 0.0581	as candi
				two pro
	$P(X \geq 4) = 1 - P(X \leq 3) = 1 - 0.9891 = 0.0109 < 5\%$	(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	Condon
	4 lies in the critical region, so significant,			not P(X
	There is evidence to suggest that the proportion of faulty frames has increased.	(E1)		

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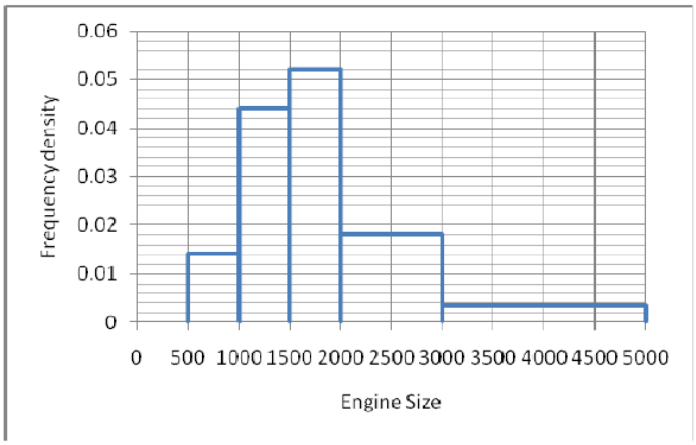
Question			Answer	Marks	
6	(i)			M1	At least 4 fds correct fo M1 can be also be gained f 18, 3.5 (at least 4 correct) and or freq per 500 - 7, 22, 26, 9, 1.7 Accept any suitable unit for fd, eg f FD per 1000 Allow fds correct to at least three dp If fd not explicitly given, M1 A1 ca heights correct (within one square) c if at least 4 correct) Allow restart with correct heights if
				A1 G1 (L1)	For fd's all correct linear scales on both axes and label c Label required on vert axis **IN REL** ie fd or frequency density or if relev fd/1000, but allow fd×1000, etc) Accept f/w or f/cw (freq/width or fre Ignore horizontal label and allow ho 500 Can also be gained from an accurate
			INCORRECT DIAGRAMS: Frequency diagrams can get M0, A0, G0, G1, G0 MAXIMUM Thus frequency density = frequency × width, frequency/midpoint etc gets MAX M0A0G0G1G0 **Frequency polygons MAX M1A1G0G0G0**	G1 (W1)	Width of bars Must be drawn at 500, 1000etc NOT GAPS ALLOWED Must have linear scale. No inequality labels on their own su but allow if a clear horizontal linear

Engine size	Frequency	Group width	Frequency density
$500 \leq x \leq 1000$	7	500	0.014
$1000 < x \leq 1500$	22	500	0.044
$1500 < x \leq 2000$	26	500	0.052
$2000 < x \leq 3000$	18	1000	0.018
$3000 < x \leq 5000$	7	2000	0.0035



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Question			Answer	Marks	Guidance
				G1(H1) [5]	Height of bars FT of heights *dep* on at lea… agree with their fds If fds not given and one height is… M1A0G1G1G0 – visual check only (within one squa… precisely
6	(ii)		Do not know exact highest and lowest values so cannot tell what the midrange is. **OR** No and a counterexample to show it may not be 2750 **OR** (500 + 5000) / 2 = 2750. But very unlikely to be absolutely correct but probably close to the true value. Some element of doubt needed. Allow 'Likely to be correct'	E1 [1]	Allow comment such as 'Highest val… lowest could be 500 therefore midra… NO mark if incorrect calculation Sight of 1750 AND 3000 (min and m… E1
6	(iii)		Mean = $\frac{(750\times 7)+(1250\times 22)+(1750\times 26)+(2500\times 18)+(4000\times 7)}{80}$ $=\frac{151250}{80}=1891$ $\Sigma x^2 f=(750^2\times 7)+(1250^2\times 22)+(1750^2\times 26)+(2500^2\times 18)+(4000^2\times 7)$ = 3937500 + 34375000 + 79625000 + 112500000 + 112000000 =342437500 $Sxx=342437500-\frac{151250^2}{80}=56480469$ $s=\sqrt{\frac{56480469}{79}}=\sqrt{714943}=846$ Only an estimate since the data are grouped.	M1 A1 M1 A1 E1 indep [5]	For midpoints (at least 3 correct) No marks for mean or sd unless usin… Answer must **NOT** be left as improp… CAO Accept correct answers for mean (18… or 846 or 845.5) from calculator eve… For sum of at least 3 correct multiple… Allow M1 for anything which round… Only penalise once in part (iii) for o… mean and standard deviation both o… Allow SC1 for RMSD 840.2 or 840 Or for any mention of midpoints or… or 'data are not exact' oe

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Question			Answer	Marks	ance
6	(iv)		$\bar{x} - 2s = 1891 - (2\times 846) = 199$ Allow 200	M1	For either. FT any positive mean and Only follow through numeric s, so if a candidate does not find is 40.76+ 2 × standard deviation', No marks in (iv) unless using $\bar{x} + 2s$
			$\bar{x} + 2s = 1891 + (2\times 846) = 3583$ Allow 3580 or 3600	A1	For both (FT) Do **NOT** penalise over specification answer
			So there are probably some outliers	E1	Must include an element of doubt Dep on upper limit in range 3000 – Allow comments such as 'any value Ignore comments about possible out
				[3]	
6	(v)		Number of cars over 2000 cm^3 = 25/80 × 2.5 million = 781250 So duty raised = 781250 × £1000 = £781 million	M1 M1 indep A1	For 25/80× 2.5 million or (18+7) /80 For something × £1000 even if this i CAO NB £781250000 is over specified so
				[3]	
6	(vi)		Because the numbers of cars sold with engine size greater than 2000 cm^3 might be reduced due to the additional duty.	E1	Allow any other reasonable suggesti Condone 'sample may not be repres Allow 'sample is not of **NEW** cars'
				[1]	

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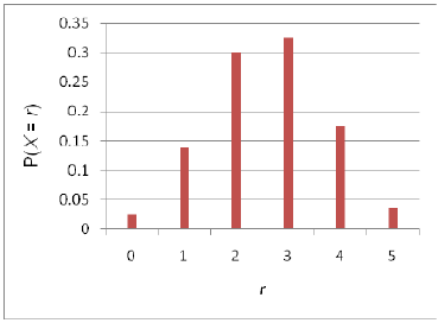
Question			Answer	Marks	ance
7	(i)		$P(X = 0) = 0.4 \times 0.5^4 = 0.025$ **NB ANSWER GIVEN**	M1 A1 **[2]**	For 0.5^4
7	(ii)		$P(X = 1) = (0.6 \times 0.5^4) + (4 \times 0.4 \times 0.5 \times 0.5^3)$ $= 0.0375 + 0.1 = 0.1375$ **NB ANSWER GIVEN**	M1* M1* M1* dep A1 **[4]**	For 0.6×0.5^4 seen as a single te by anything) For $4 \times 0.4 \times 0.5^4$ Allow 4×0.025 Watch out for incorrect methods suc 0.1 **MUST** be justified For sum of both , dep on both M1's
7	(iii)			G1 G1 **[2]**	For labelled linear scales on both ax Dep on attempt at vertical line chart axis For heights – visual check only but l and fifth taller than second and fourt Lines must be thin (gap width > line Zero if vertical scale not linear Everything correct but joined up top Everything correct but f poly G0G1 Everything correct but bar chart G0 Curve only (no vertical lines) gets G Best fit line G0G0 Allow transposed diagram

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Question			Answer	Marks	Guidance
7	(iv)		'Negative' or 'very slight negative'	E1 **[1]**	E0 for symmetrical but E1 for (very slight) neg mention symmetrical Ignore any reference to unimoda
7	(v)		E(X) = (0×0.025) + (1×0.1375) + (2×0.3) + (3×0.325) + (4×0.175) + (5×0.0375) = 2.6 E(X^2) = (0×0.025) + (1×0.1375) + (4×0.3) + (9×0.325) + 16×0.175) + (25×0.0375) = 0 + 0.1375 + 1.2 + 2.925 + 2.8 + 0.9375 = 8 Var (X) = 8 – 2.6^2 = 1.24	M1 A1 M1* M1* dep A1 **[5]**	For Σrp (at least 3 terms correct) CAO For $\Sigma r^2 p$ (at least 3 terms correct) for – their E(X)² FT their E(X) provided Var(X) > 0 USE of E(X-μ)^2 gets M1 for attempt $2.6)^2$, $(-1.6)^2$, $(-0.6)^2$, 0.4^2, 1.4^2, 2.4^2 their E(X)) (all 5 correct for M1), th least 3 terms correct) Division by 5 or other spurious valu M1A1M1M1A0, or M1A0M1M1A0 5. Unsupported correct answers get 5 n
7	(vi)		P(Total of 3) = (3×0.325×0.025^2) + (6×0.3×0.1375×0.025) + 0.1375^3 = 3 × 0.000203 + 6 × 0.001031 + 0.002600= 0.000609 + 0.006188 + 0.002600 = 0.00940 (= 3×13/64000 + 6×33/32000 + 1331/512000)	M1 M1 M1 A1 **[4]**	For decimal part of first term 0.325× For decimal part of second term 0.3× For third term – ignore extra coeffic All M marks above depend on triple CAO: AWRT 0.0094. Allow 0.009

NOTE RE OVER-SPECIFICATION OF ANSWERS

If answers are grossly over-specified, deduct the final answer mark in every case. Probabilities should also be rounded to a se accuracy. In general final non probability answers should not be given to more than 4 significant figures. Allow probabilities general accept answers which are correct to 3 significant figures when given to 4 or 5 significant figures.

If answer given as a fraction and as an over-specified decimal – ignore decimal and mark fraction.

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ADDITIONAL NOTES RE Q5

Comparison with 95% method
If 95% seen anywhere then
B1 for P($X \leq 3$)
B1 for 0.9891
M1* for comparison with 95% dep on B1
A1* for significant oe
E1*

Smallest critical region method:

Either:
Smallest critical region that 4 could fall into is {4,5,6,7,8,9,10,11,12,13,14,15, 16, 17, 18} gets B1 and has size 0.0109 gets B
M1*, A1*, E1* as per scheme
NB These marks only awarded if 4 used, not other values.

Use of k method with no probabilities quoted:

$P(X \geq 3) = 1 - P(X \leq 2) > 5\%$
$P(X \geq 4) = 1 - P(X \leq 3) < 5\%$
These may be seen in terms of k or n.
Either $k = 4$ or $k - 1 = 3$ so $k = 4$ gets SC1
so CR is {4,5,6,7,8,9,10,11,12,13,14,15, 16, 17, 18} gets another SC1and conclusion gets another SC1

Use of k method with one probability quoted:

$1 - 0.9891 < 5\%$ or $0.0109 < 5\%$ gets B0B1M1
$P(X \leq k - 1) = P(X \leq 3)$
so $k - 1 = 3$ so $k = 4$ (or just $k = 8$)
so CR is {4,5,6,7,8,9,10,11,12,13,14,15, 16, 17, 18} and conclusion gets A1E1

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Two tailed test done but with correct H_1: $p>0.05$
Hyp gets max B1B1B1
if compare with 5% ignore work on lower tail and mark upper tail as per scheme but withhold A1E1
if compare with 2.5% no marks B0B0M0A0E0

Line diagram method
B1 for squiggly line between 3 and 4 or on 4 exclusively (ie just one line), B1*dep* for arrow pointing to right, M1 0.0109 seen squiggly line or from 4, A1E1 for correct conclusion

Bar chart method
B1 for line clearly on boundary between 3 and 4 or within 4 block exclusively (ie just one line), B1*dep* for arrow pointing to ri on diagram from boundary line or from 8, A1E1 for correct conclusion.

Using P(Not faulty) method
H_0: $p=0.95$, H_1: $p<0.95$ where p represents the prob that a frame is faulty gets B1B1B1.
$P(X\leq 14)=0.0109 < 5\%$ So significant, etc gets B1B1M1A1E1

NB
If H_0: $p=0.5$, H_1: $p>0.5$, etc seen, but then revert to 0.05 in working allow marks for correct subsequent working. However if 0 throughout, then max B1 for definition of p and possibly B1 for notation $P(X \geq 4)$.