

## **Mathematics (MEI)**

Advanced Subsidiary GCE

**Unit 4766: Statistics 1**

# **Mark Scheme for June 2012**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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## Annotations

Annotation in scoris	Meaning
✓ and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR SC SC this year as MR symbol missing	Misread
Highlighting	
Other abbreviations in mark scheme	Meaning
E1	Mark for explaining
U1	Mark for correct units
G1	Mark for a correct feature on a graph
M1 dep*	Method mark dependent on a previous mark, indicated by *
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
awrt	Answer which rounds to

**Subject-specific Marking Instructions**

a. Annotations should be used whenever appropriate during your marking.

**The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks.** It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c. The following types of marks are available.

**M**

A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

**A**

Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

**B**

Mark for a correct result or statement independent of Method marks.

**E**

A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

Unless otherwise indicated, marks once gained cannot subsequently be lost, eg wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep \*' is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (eg 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g. Rules for replaced work

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others.

NB Follow these maths-specific instructions rather than those in the assessor handbook.

h. For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

Question		Answer	Marks	Guidance
1	(i)	$P(\text{All blue}) = \frac{30}{50} \times \frac{29}{49} \times \frac{28}{48} = 0.2071$ <p><b>OR</b></p> $\binom{30}{3} / \binom{50}{3} = 4060/19600 = 29/140 = 0.2071$ <p>M2 for the complete method</p>	M1 M1 A1 [3]	For $\frac{30}{50} \times$ (as part of a triple product) For product of other two fractions CAO SC2 for $P(\text{All red}) = 0.0582$
1	(ii)	$P(\text{All red}) = \frac{20}{50} \times \frac{19}{49} \times \frac{18}{48} = 0.0582 \text{ or } \binom{20}{3} / \binom{50}{3} = 0.0582$ <p><b>OR</b></p> $P(\text{At least one of each colour}) = 1 - (0.2071 + 0.0582) = 0.7347$ $\text{or } 1 - \left( \frac{29}{140} + \frac{57}{980} \right) = 1 - \frac{260}{980} = 1 - \frac{13}{49} = \frac{36}{49}$ <p><math>P(2b,1r) + P(1b,2r)</math></p>	M1 M1 A1 [3] (M1)	For $P(\text{All red})$ For $1 - (0.2071 + 0.0582)$ CAO For either $\frac{30}{50} \times \frac{29}{49} \times \frac{20}{48}$ or $\frac{20}{50} \times \frac{19}{49} \times \frac{30}{48}$ SC2 for $1 - (30/50)^3 - (20/50)^3 = 1 - 0.216 - 0.064 = 0.72$ , providing consistent with (i) . If not consistent with (i) M0M0A0

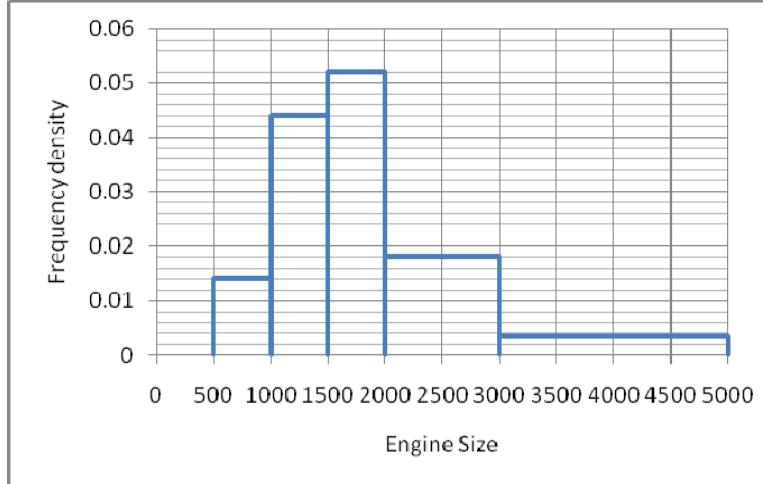
Question		Answer	Marks	Guidance	
		$= 3 \times \frac{30}{50} \times \frac{29}{49} \times \frac{20}{48} + 3 \times \frac{20}{50} \times \frac{19}{49} \times \frac{30}{48}$ $= 3 \times 0.1480 + 3 \times 0.0969 = 0.7347$ <b>OR</b> Either $\binom{30}{2} \times \binom{20}{1} / \binom{50}{3}$ or $\binom{30}{1} \times \binom{20}{2} / \binom{50}{3}$	(M1)  (A1)  (M1)  (M1) (A1)	For sum of both or for $3 \times$ either  CAO  For sum of both CAO	NB M2 also for $\frac{30}{50} \times \frac{20}{49} \left( \times \frac{48}{48} \right)$ even if not multiplied by 3 Allow 0.73 or better with working
2	(i)	${}^9C_3 \times {}^5C_3 = 84 \times 10 = 840$	M1 M1 A1 [3]	For either ${}^9C_3$ or ${}^5C_3$ For product of both correct combinations CAO	Zero for permutations
2	(ii)	Total number of ways of answering 6 from 14 is ${}^{14}C_6 = 3003$ $\text{Probability} = \frac{840}{3003} = \frac{40}{143} = 0.27972 = 0.280$ <b>OR</b> ${}^6C_3 \times \frac{5}{14} \times \frac{4}{13} \times \frac{3}{12} \times \frac{9}{11} \times \frac{8}{10} \times \frac{7}{9} = 0.280$	M1 M1 A1 [3]  (M1)  (M1) (A1)	For ${}^{14}C_6$ seen in part (ii) For their 840/3003 or their 840/ ${}^{14}C_6$ FT their 840  For product of fractions For ${}^6C_3 \times$ correct product	Allow full marks for unsimplified fractional answers  SC1 for ${}^6C_3 \times (5/14)^3 \times (9/14)^3 = 0.2420$

Question		Answer	Marks	Guidance
3	(i)	$X \sim B(30, 0.85)$ $P(X = 29) = \binom{30}{29} \times 0.85^{29} \times 0.15^1 = 30 \times 0.0013466 = 0.0404$	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 With $p + q = 1$ Allow 0.04 www If further working (EG $P(X=29) - P(X=28)$ ) give M2A0
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 eg $0.04+0.0076=0.0476$ Allow 0.05 with working
3	(iii)	Expected number = $10 \times 0.0480 = 0.480$	M1 A1 [2]	For $10 \times$ their (ii) FT their (ii) but if answer to (ii) leads to a whole number for (iii) give M1A0 <b>provided (ii) between 0 and 1</b> Do not allow answer rounded to 0 or 1.

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 SC1 for 'without replacement' method $92/100 \times 91/99 \times 8/98 = 0.0690$
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 $0.92 \times 0.08$ FT their 0.0677 SC1 for answer of 0.143 from 'without replacement' method
4	(ii)	P(At least one of first 20) = $1 - P(\text{None of first 20})$  $= 1 - 0.92^{20} = 1 - 0.1887 = 0.8113$	M1   M1 A1 [3]	0.92 <sup>20</sup> 1 - 0.92 <sup>20</sup> CAO Accept answer of 0.81 or better from $P(1) + P(2) + \dots$ , or SC2 if all correct working shown but wrong answer No marks for 'without replacement' method Allow 0.81 with working but not 0.812

Question		Answer	Marks	Guidance
5		<p>Let <math>p</math> = probability that a randomly selected frame is faulty</p> <p><math>H_0: p = 0.05</math></p> <p><math>H_1: p &gt; 0.05</math></p> <p><math>P(X \geq 4)</math></p> <p><math>= 1 - P(X \leq 3) = 1 - 0.9891 = 0.0109</math></p>	B1 B1 B1 B1*	<p>For definition of <math>p</math> in context Minimum needed for B1 is <math>p</math> = probability that frame/bike is faulty. Do not allow is <math>p</math> = probability that it is faulty Allow <math>p = P(\text{frame faulty})</math> Definition of <math>p</math> 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 <math>H_0</math> as long as it is a clear definition ' <math>p</math> = the probability that frame is faulty, NOT just a sentence 'probability is 0.05' Do NOT allow '<math>p</math> = the probability that faulty frames have increased'</p> <p><math>H_0: p(\text{frame faulty}) = 0.05, H_1: p(\text{frame faulty}) &gt; 0.05</math> gets B0B1B1 Allow <math>p=5\%</math>, allow <math>\theta</math> or <math>\pi</math> and <math>\rho</math> but not <math>x</math>. However allow any single symbol <u>if defined</u> Allow <math>H_0 = p=0.05</math>, Allow <math>H_0: p=1/20</math> Do not allow <math>H_0: P(X=x) = 0.05, H_1: P(X=x) &gt; 0.05</math> Do not allow <math>H_0: =0.05, =5\%, P(0.05), p(0052), p(x)=0.05, x=0.05</math> (unless <math>x</math> correctly defined as a probability) Do not allow <math>H_1: p \geq 0.05</math>, Do not allow <math>H_0</math> and <math>H_1</math> reversed Allow NH and AH in place of <math>H_0</math> and <math>H_1</math> 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.</p> <p>For notation <math>P(X \geq 4)</math> or <math>1 - P(X \leq 3)</math> This mark may be implied by 0.0109 as long as no incorrect notation.</p> <p>For 0.0109, indep of previous mark</p> <p>No further marks if point probs used - <math>P(X = 4) = 0.0094</math> DO NOT FT wrong <math>H_1</math> But if <math>H_1</math> is <math>p \geq 0.05</math> allow the rest of the marks if earned so max 7/8 Or for <math>1 - 0.9891</math></p>

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

Question		Answer				Marks	Guidance																					
6	(i)	<table border="1"> <thead> <tr> <th>Engine size</th><th>Frequency</th><th>Group width</th><th>Frequency density</th></tr> </thead> <tbody> <tr> <td><math>500 \leq x \leq 1000</math></td><td>7</td><td>500</td><td>0.014</td></tr> <tr> <td><math>1000 &lt; x \leq 1500</math></td><td>22</td><td>500</td><td>0.044</td></tr> <tr> <td><math>1500 &lt; x \leq 2000</math></td><td>26</td><td>500</td><td>0.052</td></tr> <tr> <td><math>2000 &lt; x \leq 3000</math></td><td>18</td><td>1000</td><td>0.018</td></tr> <tr> <td><math>3000 &lt; x \leq 5000</math></td><td>7</td><td>2000</td><td>0.0035</td></tr> </tbody> </table> 	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	M1	<p>At least 4 fds correct for M1 M1 can be also be gained from freq per 1000 – 14, 44, 52, 18, 3.5 (at least 4 correct) and A1 for all correct or freq per 500 - 7, 22, 26, 9, 1.75 Accept any suitable unit for fd, eg freq per 1000, BUT NOT FD per 1000 Allow fds correct to at least three dp If fd not explicitly given, M1 A1 can be gained from all heights correct (within one square) on histogram (and M1A0 if at least 4 correct) Allow restart with correct heights if given fd wrong</p>
Engine size	Frequency	Group width	Frequency density																									
$500 \leq x \leq 1000$	7	500	0.014																									
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				A1 G1(L1)	<p>For fd's all correct   linear scales on both axes and label on vertical axis Label required on vert axis <b>IN RELATION</b> to first M1 mark ie fd or frequency density or if relevant freq/1000, etc (NOT fd/1000, but allow fd×1000, etc) Accept f/w or f/cw (freq/width or freq/class width) Ignore horizontal label and allow horizontal scale to start at 500  Can also be gained from an accurate key</p>																							
		<p><u>INCORRECT DIAGRAMS:</u> Frequency diagrams can get M0, A0, G0, G1, G0 MAXIMUM Thus frequency density = frequency × width, frequency/midpoint etc gets MAX M0A0G0G1G0 <b>Frequency polygons MAX M1A1G0G0G0</b></p>	G1(W1)	<p>Width of bars Must be drawn at 500, 1000etc NOT 499.5 or 500.5 etc NO GAPS ALLOWED Must have linear scale. No inequality labels on their own such as <math>500 \leq S &lt; 1000</math>, etc but allow if a clear horizontal linear scale is also given.</p>																								

Question		Answer	Marks	Guidance
			G1(H1) [5]	Height of bars FT of heights dep on at least 3 heights correct and all must agree with their fds If fds not given and one height is wrong then max M1A0G1G1G0 – visual check only (within one square) –no need to measure precisely
6	(ii)	<p>Do not know exact highest and lowest values so cannot tell what the midrange is.</p> <p><u>OR</u></p> <p>No and a counterexample to show it may not be 2750</p> <p><u>OR</u></p> <p><math>(500 + 5000) / 2 = 2750</math>. But very unlikely to be absolutely correct but probably close to the true value. Some element of doubt needed. Allow 'Likely to be correct'</p>	E1 [1]	<p>Allow comment such as 'Highest value could be 5000 and lowest could be 500 therefore midrange could be 2750' NO mark if incorrect calculation</p> <p>Sight of 1750 AND 3000 (min and max of midrange) scores E1</p>
6	(iii)	<p>Mean =</p> $\frac{(750 \times 7) + (1250 \times 22) + (1750 \times 26) + (2500 \times 18) + (4000 \times 7)}{80}$ $= \frac{151250}{80} = 1891$ $\Sigma x^2 f = (750^2 \times 7) + (1250^2 \times 22) + (1750^2 \times 26) + (2500^2 \times 18) + (4000^2 \times 7)$ $= 3937500 + 34375000 + 79625000 + 112500000 + 112000000$ $= 342437500$ $S_{xx} = 342437500 - \frac{151250^2}{80} = 56480469$ $s = \sqrt{\frac{56480469}{79}} = \sqrt{714943} = 846$ <p>Only an estimate since the data are grouped.</p>	M1 A1 M1 A1 E1 indep [5]	<p>For midpoints (at least 3 correct) No marks for mean or sd unless using midpoints Answer must <u>NOT</u> be left as improper fraction CAO Accept correct answers for mean (1890 or 1891) and sd (850 or 846 or 845.5) from calculator even if eg wrong <math>S_{xx}</math> given For sum of at least 3 correct multiples <math>fx^2</math> Allow M1 for anything which rounds to 342400000</p> <p>Only penalise once in part (iii) for over specification, even if mean and standard deviation both over specified. Allow SC1 for RMSD 840.2 or 840 from calculator Or for any mention of midpoints or 'don't have actual data' or 'data are not exact' oe</p>

Question		Answer	Marks	Guidance
6	(iv)	$\bar{x} - 2s = 1891 - (2 \times 846) = 199$ Allow 200  $\bar{x} + 2s = 1891 + (2 \times 846) = 3583$ Allow 3580 or 3600  So there are probably some outliers	M1  A1  E1  <b>[3]</b>	For either. FT any positive mean and their positive sd/rmsd for M1 Only follow through numerical values, not variables such as $s$ , so if a candidate does not find $s$ but then writes here 'limit is $40.76 + 2 \times \text{standard deviation}$ ', do NOT award M1 No marks in (iv) unless using $\bar{x} + 2s$ or $\bar{x} - 2s$ For both (FT) Do NOT penalise over specification here as it is not the final answer Must include an element of doubt Dep on upper limit in range 3000 – 5000 Allow comments such as 'any value over 3583 is an outlier' Ignore comments about possible outliers at lower end.
6	(v)	Number of cars over $2000 \text{ cm}^3 = 25/80 \times 2.5 \text{ million} = 781250$ So duty raised = $781250 \times \text{£}1000 = \text{£}781 \text{ million}$	M1 M1 indep A1  <b>[3]</b>	For $25/80 \times 2.5 \text{ million}$ or $(18+7)/80 \times 2.5 \text{ million}$ For something $\times \text{£}1000$ even if this is the first step  CAO NB £781250000 is over specified so only 2/3
6	(vi)	Because the numbers of cars sold with engine size greater than $2000 \text{ cm}^3$ might be reduced due to the additional duty.	E1  <b>[1]</b>	Allow any other reasonable suggestion Condone 'sample may not be representative' Allow 'sample is not of NEW cars'

Question		Answer	Marks	Guidance
7	(i)	$P(X = 0) = 0.4 \times 0.5^4 = 0.025$ <b>NB ANSWER GIVEN</b>	M1 A1 [2]	For $0.5^4$
7	(ii)	$\begin{aligned} P(X = 1) &= (0.6 \times 0.5^4) + (4 \times 0.4 \times 0.5 \times 0.5^3) \\ &= 0.0375 + 0.1 = 0.1375 \quad \text{NB ANSWER GIVEN} \end{aligned}$	M1* M1* M1* dep A1 [4]	<p>For <math>0.6 \times 0.5^4</math> seen as a single term (not multiplied or divided by anything)</p> <p>For <math>4 \times 0.4 \times 0.5^4</math> Allow <math>4 \times 0.025</math></p> <p>Watch out for incorrect methods such as <math>(0.4/4)</math></p> <p>0.1 <b>MUST</b> be justified</p> <p>For sum of both, dep on both M1's</p>
7	(iii)		G1 G1 [2]	<p>For labelled linear scales on both axes Dep on attempt at vertical line chart. Accept P on vertical axis</p> <p>For heights – visual check only but last bar taller than first and fifth taller than second and fourth taller than third. Lines must be thin (gap width &gt; line width). All correct. Zero if vertical scale not linear Everything correct but joined up tops G0G1 MAX Everything correct but f poly G0G1 MAX Everything correct but bar chart G0G1 MAX Curve only (no vertical lines) gets G0G0 Best fit line G0G0 Allow transposed diagram</p>

Question		Answer	Marks	Guidance
7	(iv)	'Negative' or 'very slight negative'	E1 [1]	E0 for symmetrical but E1 for (very slight) negative skewness even if also mention symmetrical Ignore any reference to unimodal
7	(v)	$\begin{aligned} E(X) &= (0 \times 0.025) + (1 \times 0.1375) + (2 \times 0.3) + (3 \times 0.325) + (4 \times 0.175) \\ &\quad + (5 \times 0.0375) \\ &= 2.6 \end{aligned}$ $\begin{aligned} E(X^2) &= (0 \times 0.025) + (1 \times 0.1375) + (4 \times 0.3) + (9 \times 0.325) + 16 \times 0.175 \\ &\quad + (25 \times 0.0375) = 0 + 0.1375 + 1.2 + 2.925 + 2.8 + 0.9375 = 8 \end{aligned}$ $\text{Var}(X) = 8 - 2.6^2$ $= 1.24$	M1 A1  M1* M1* dep A1 [5]	For $\sum rp$ (at least 3 terms correct) CAO  For $\sum r^2 p$ (at least 3 terms correct) for – their $E(X)^2$  FT their $E(X)$ provided $\text{Var}(X) > 0$ USE of $E(X-\mu)^2$ gets M1 for attempt at $(x-\mu)^2$ should see $(-2.6)^2, (-1.6)^2, (-0.6)^2, 0.4^2, 1.4^2, 2.4^2$ (if $E(X)$ correct but FT their $E(X)$ ) (all 5 correct for M1), then M1 for $\sum p(x-\mu)^2$ (at least 3 terms correct) Division by 5 or other spurious value at end gives max M1A1M1M1A0, or M1A0M1M1A0 if $E(X)$ also divided by 5. Unsupported correct answers get 5 marks.
7	(vi)	$\begin{aligned} P(\text{Total of 3}) &= (3 \times 0.325 \times 0.025^2) + (6 \times 0.3 \times 0.1375 \times 0.025) + \\ &\quad 0.1375^3 = 3 \times 0.000203 + 6 \times 0.001031 + 0.002600 = \\ &\quad 0.000609 + 0.006188 + 0.002600 = 0.00940 \\ &= 3 \times 13/64000 + 6 \times 33/32000 + 1331/512000 \end{aligned}$	M1 M1  M1 A1 [4]	For decimal part of first term $0.325 \times 0.025^2$ For decimal part of second term $0.3 \times 0.1375 \times 0.025$  For third term – ignore extra coefficient All M marks above depend on triple probability products CAO: AWRT 0.0094. Allow 0.009 with working.

#### 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 sensible degree of accuracy. In general final non probability answers should not be given to more than 4 significant figures. Allow probabilities given to 5 sig fig. In 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.

**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 B1, This is  $< 5\%$  gets 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 SC1 and conclusion gets another SC1

**Use of  $k$  method with one probability quoted:**

$$1 - 0.9891 < 5\% \text{ or } 0.0109 < 5\% \text{ gets B0B1M1}$$

$$P(X \leq k - 1) = P(X \leq 3)$$

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

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 on diagram from 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 right, M1 0.0109 seen on diagram from boundary line or from 8, A1E1 for correct conclusion.

#### Using $P(\text{Not faulty})$ 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 0.5 used consistently throughout, then max B1 for definition of p and possibly B1 for notation  $P(X \geq 4)$ .

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