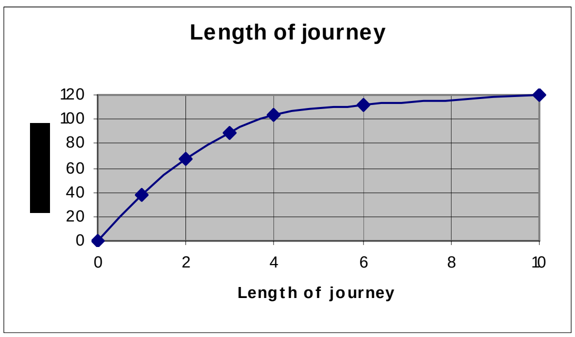
Mark Scheme 4766
June 2005

Statistics 1 (4766)

Qn	Answer	Mk	Comment
1 (i)	Mean = 657/20 = 32.85	B1 cao	
	Variance = $\frac{1}{19}(22839 - \frac{657^2}{20}) = 66.13$	M1 A1 cao	
(ii)	Standard deviation = 8.13		
	32.85 + 2(8.13) = 49.11	M1 ft	Calculation of 49.11
	none of the 3 values exceed this so no outliers	A1 ft	
2 (i)		G1 G1 G1	For calculating 38,68,89,103,112,120 Plotting end points Heights inc (0,0)
(ii)	Median = 1.7 miles	B1	
	Lower quartile = 0.8 miles	M1	
	Upper quartile = 3 miles	M1	
	Interquartile range = 2.2 miles	A1 ft	
(iii)	The graph exhibits positive skewness	E1	

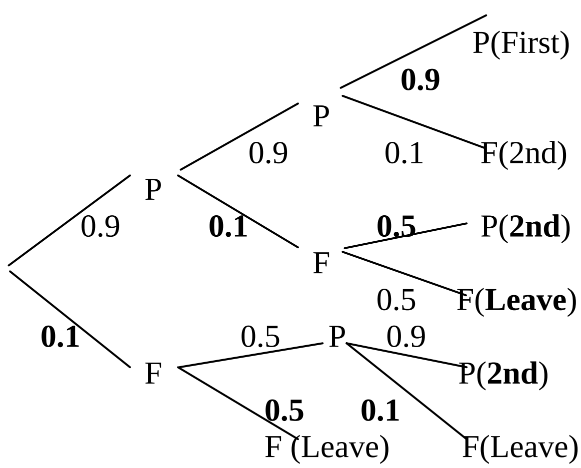
Statistics 1 (4766) June 2005 **Final Mark Scheme**

3 (i)	$P(X = 4) = \frac{1}{40}(4)(5) = \frac{1}{2}$ (Answer given)	B1	Calculation must be seen
(ii)	$E(X) = (2+12+36+80)\frac{1}{40}$ So $E(X) = 3.25$	M1 A1 cao	Sum of rp
	$\text{Var}(X) = (2+24+108+320)\frac{1}{40} - 3.25^2$ $= 11.35 - 10.5625$ $= 0.7875$	M1 M1 dep A1 cao	Sum of r^2p -3.25^2
(iii)	Expected number of weeks = $\frac{6}{40}$ x45 = 6.75 weeks	M1 A1	Use of np
4 (i)	Number of choices = $\binom{6}{3} = 20$	M1 A1	For $\binom{6}{3}$
(ii)	Number of ways = $\binom{6}{3}\times\binom{7}{4}\times\binom{8}{5}$ $= 20\times35\times56$ $= 39200$	M1 M1 A1 cao	Correct 3 terms Multiplied
(iii)	Number of ways of choosing 12 questions $= \binom{21}{12} = 293930$ Probability of choosing correct number from each section = 39200/293930 = 0.133	M1 M1 ft A1 cao	For $\binom{21}{12}$

5 (i)	(see table below)	B1	All correct

	1	**2**	**3**	**4**	**5**	**6**
1	1	2	3	4	5	6
2	2	2	6	4	10	6
3	3	6	3	12	15	6
4	4	4	12	**4**	**20**	12
5	5	10	15	**20**	**5**	**30**
6	6	6	6	12	**30**	**6**

(ii)	(*A*) P(LCM > 6) = 1/3	B1	
	(*B*) P(LCM = 5n) = 11/36	B1	
	(*C*) P(LCM > 6 ∩ LCM = 5n) = 2/9	M1 A1 cao	Use of diagram
(iii)	$\frac{1}{3} \times \frac{11}{36} \neq \frac{2}{9}$	M1	Use of definition
	Hence events are not independent	E1	

6 (i)		G1 G1	Probabilities Outcomes
(ii)		M1	

(*A*)	P(First team) = 0.9^3 = 0.729	A1	
(*B*)	P(Second team) = $0.9\times0.9\times0.1+0.9\times0.1\times0.5+0.1\times0.9\times0.5$	M1 M1	1 correct triple 3 correct triples added
	= 0.081 + 0.045 + 0.045 = 0.171	A1	
(iii)	P(asked to leave) = 1 -0.729 – 0.171		
	= 0.1	B1	
(iv)	P(Leave after two games given leaves)		
	$= \dfrac{0.1\times0.5}{0.1} = \dfrac{1}{2}$	M1 ft A1 cao	Denominator
(v)	P(at least one is asked to leave)	M1 ft M1 A1 cao	Calc'n of 0.9 1 – ( )³
	$=1-0.9^3$ = 0.271		
(vi)	P(Pass a total of 7 games)		
	=P(First, Second, Second) + P(First, First, Leave after three games)	M1 M1 ft	Attempts both $0.729(0.171)^2$
	$= 3\times0.729\times0.171^2 + 3\times0.729^2\times0.05$	M1 ft	$0.05(0.729)^2$
	= 0.064 + 0.080 = 0.144	M1 A1 cao	multiply by 3

7 (i)	$X \sim B\left(15, \frac{1}{6}\right)$		
	$P(X=0) = \left(\frac{5}{6}\right)^{15} = 0.065$	M1 A1 cao	$\left(\frac{5}{6}\right)^{15}$
(ii)	$P(X=4) = \binom{15}{4}\times\left(\frac{1}{6}\right)^4\times\left(\frac{5}{6}\right)^{11}$	M1	$\left(\frac{1}{6}\right)^4\left(\frac{5}{6}\right)^{11}$
	= 0.142 (or 0.9102-0.7685)	M1 A1 cao	multiply by $\binom{15}{4}$

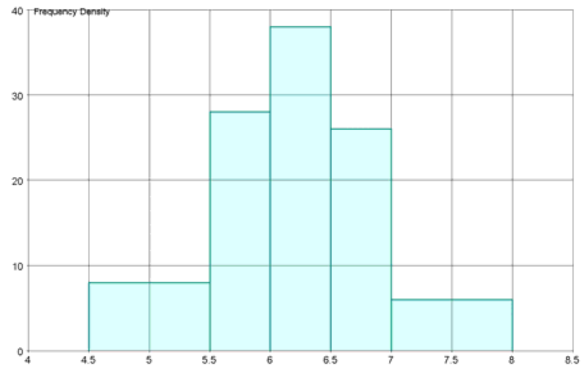
(iii)	$P(X > 3) = 1 - P(X \le 3)$ $= 1 - 0.7685 = 0.232$	M1 A1	
(iv) (*A*)	Let p = probability of a six on any throw $H_0 : p = \frac{1}{6}$ $H_1 : p < \frac{1}{6}$ $X \sim B\left(15, \frac{1}{6}\right)$ $P(X = 0) = 0.065$ 0.065 < 0.1 and so reject H_0 Conclude that there is sufficient evidence at the 10% level that the dice are biased against sixes.	B1 B1 M1 M1 dep E1 dep	Definition of p Both hypotheses 0.065 Comparison
(*B*)	Let p = probability of a six on any throw $H_0 : p = \frac{1}{6}$ $H_1 : p > \frac{1}{6}$ $X \sim B\left(15, \frac{1}{6}\right)$ $P(X \ge 5) = 1 - P(X \le 4) = 1 - 0.910 = 0.09$ 0.09 < 0.1 and so reject H_0 Conclude that there is sufficient evidence at the 10% level that the dice are biased in favour of sixes.	B1 M1 M1 dep E1 dep	Both hypotheses 0.09 Comparison
(v)	Conclusions contradictory. Even if null hypothesis is true, it will be rejected 10% of the time purely by chance. Or other sensible comments.	E1 E1	Contradictory By chance

Mark Scheme 4766
January 2006

Q 1 **(i)**	The range = 55 – 15 = 40 The interquartile range = 35 – 26 = 9	B1 CAO B1 CAO	**2**
(ii)	35 + 1.5 x 9 = 48.5 26 – 1.5 x 9 = 12.5 Any value > 48.5 is an outlier (so 55 will be an outlier),	M1 for 48.5 oe M1 for 12.5 oe A1 (FT their IQR in (i))	**3**
(iii)	One valid comment such as eg: Positively skewed Middle 50% of data is closely bunched	E1	**1**
		TOTAL	**6**
2 **(i)**	Impossible because if 3 letters are correct, the fourth must be also.	E1	**1**
(ii)	There is only one way to place letters correctly. There are 4! = 24 ways to arrange 4 letters. OR: $\frac{1}{4}$ x $\frac{1}{3}$ x $\frac{1}{2}$ NOTE: **ANSWER GIVEN**	E1 E1 B1 for $\frac{1}{4}$ x $\frac{1}{3}$ B1 for x $\frac{1}{2}$	**2**
(iii)	E(X) = 1 x $\frac{1}{3}$ + 2 x $\frac{1}{4}$ + 4 x $\frac{1}{24}$ = 1 E(X^2) = 1 x $\frac{1}{3}$ + 4 x $\frac{1}{4}$ + 16 x $\frac{1}{24}$ = 2 So Var(X) = 2 – 1^2 = 1	M1 For $\sum xp$ (at least 2 non-zero terms correct) A1 CAO M1 for $\sum \boldsymbol{x}^2\boldsymbol{p}$ (at least 2 non-zero terms correct) M1*dep* for – their E(X)² A1 FT their E(X) provided Var(X) > 0	**5**
		TOTAL	**8**

3 **(i)**	$X \sim B(10,0.2)$ $P(X < 4) = P(X \leq 3) = 0.8791$ OR attempt to sum $P(X = 0,1,2,3)$ using $X \sim B(10,0.2)$ can score M1, A1	M1 for $X \leq 3$ A1	**2**
(ii)	Let p = the probability that a bowl is imperfect $H_0 : p = 0.2 \qquad H_1 : p < 0.2$ $X \sim B(20,0.2)$ $P(X \leq 3) = 0.2061$ $0.2061 > 5\%$ Cannot reject H_0 and so insufficient evidence to claim a reduction. OR using critical region method: CR is {0} B1, 2 not in CR M1, A1 as above	B1 Definition of p B1, B1 B1 for 0.2061 seen M1 for this comparison A1 *dep* for comment <u>in context</u>	**3** **3**
		TOTAL	**8**
4 **(i)**	The company could increase the mean weight. The company could decrease the standard deviation.	B1 CAO B1	**2**
(ii)	Sample mean = 11409/25 = 456.36 $S_{xx} = 5206937 - \dfrac{11409^2}{25} = 325.76$ Sample s.d = $\sqrt{\dfrac{325.76}{24}}$ =3.68	B1 M1 for S_{xx} A1	**3**
		TOTAL	**5**
5 **(i)**	P(A ∩ B) = 0.4	B1 CAO	**1**
(ii)	P(C U D) = 0.6	B1 CAO	**1**
(iii)	Events B and C are mutually exclusive.	B1 CAO	**1**
(iv)	P(B) = 0.6, P(D) = 0.4 and P(B ∩ D) = 0.2 0.6 x 0.4 $\neq$ 0.2 (so B and D not independent)	B1 for P(B ∩ D) = 0.2 soi E1	**2**
		TOTAL	**5**
6 **(i)**	Number of selections = $\binom{12}{7}$ = 792	M1 for $\binom{12}{7}$ A1 CAO	**2**
(ii)	Number of arrangements = 7! = 5040	M1 for 7!, A1 CAO	**2**
		TOTAL	**4**

<table>
<tr><td>7
(i)</td><td>Mean score = (2x8 + 3x7 + 4x6 + 5 + 4)/11 =

6.36</td><td>M1 for $\sum fx/11$
A1 CAO</td><td>2</td></tr>
<tr><td>(ii)</td><td>
Mean GCSE Score</td><td>G1 Linear sensible scales

G1 fds of 8, 28, 38, 26, 6 or 4k, 14k, 19k, 13k, 3k for sensible values of k either on script or on graph.

G1 (dep on reasonable attempt at fd) Appropriate label for vertical scale eg ‘Frequency density’, ‘frequency per ½ unit’, ‘students per mean GCSE score’. (allow Key)</td><td>3</td></tr>
<tr><td>(iii)</td><td><table>
<tr><td>Mid point, x</td><td>f</td><td>fx</td><td>fx²</td></tr>
<tr><td>5</td><td>8</td><td>40</td><td>200</td></tr>
<tr><td>5.75</td><td>14</td><td>80.5</td><td>462.875</td></tr>
<tr><td>6.25</td><td>19</td><td>118.75</td><td>742.1875</td></tr>
<tr><td>6.75</td><td>13</td><td>87.75</td><td>592.3125</td></tr>
<tr><td>7.5</td><td>6</td><td>45</td><td>337.5</td></tr>
<tr><td></td><td>60</td><td>372</td><td>2334.875</td></tr>
</table>
Sample mean = 372/60 = 6.2

$S_{xx} = 2334.875 - \frac{372^2}{60} = 28.475$

Sample s.d = $\sqrt{\frac{28.475}{59}} = 0.695$</td><td>B1 mid points

B1FT $\sum fx$ and $\sum fx^2$

B1 CAO

M1 for their S_{xx}

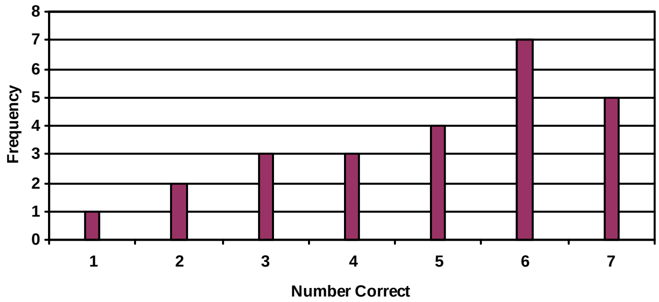
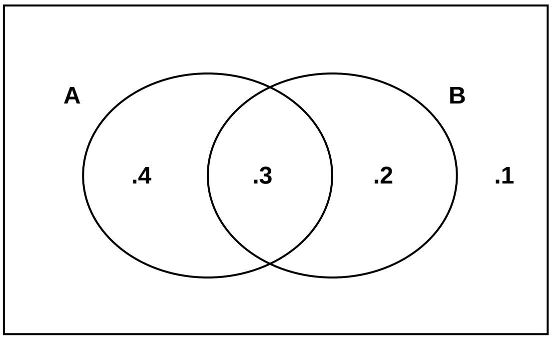
A1 CAO</td><td>5</td></tr>
<tr><td>(iv)</td><td>Prediction of score = 13 x 7.4 – 46 = 50.2
So predicted AS grade would be B</td><td>M1 For 13 x 7.4 – 46
A1 dep on 50.2 (or 50) seen</td><td>2</td></tr>
<tr><td>(v)</td><td>Prediction of score = 13 x 5.5 – 46 = 25.5

So predicted grade would be D/E
(allow D or E)
Because score roughly halfway from 20 to 30,
OR (for D) closer to D than E
OR (for E) past E but not up to D boundary</td><td>M1 For 13 x 5.5 – 46

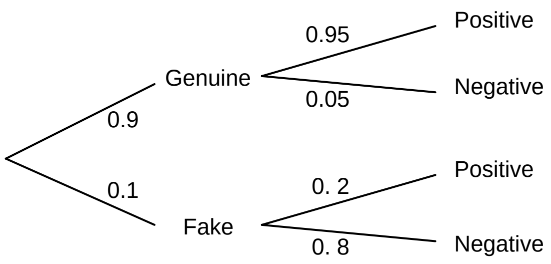
A1 dep on 25.5 (or 26 or 25) seen
E1 For explanation of conversion – logical statement/argument that supports their choice.</td><td>3</td></tr>
<tr><td>(vi)</td><td>Mean = 13 x 6.2 – 46 = 34.6
Standard deviation = 13 x 0.695 = 9.035</td><td>B1 FT their 6.2
M1 for 13 x their 0.695
A1 FT</td><td>3</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>18</td></tr>
</table>

8 **(i)**	P(all jam) $= \frac{5}{12}\times\frac{4}{11}\times\frac{3}{10}$ $= \frac{1}{22}$ = 0.04545	M1 5 x 4 x 3 or $\binom{5}{3}$ in numerator M1 12 x 11 x 10 or $\binom{12}{3}$ in denominator A1 CAO	**3**
(ii)	P(all same) $=\frac{5}{12}\times\frac{4}{11}\times\frac{3}{10} + \frac{4}{12}\times\frac{3}{11}\times\frac{2}{10} + \frac{3}{12}\times\frac{2}{11}\times\frac{1}{10}$ $= \frac{1}{22}+\frac{1}{55}+\frac{1}{220} = \frac{3}{44}$ = 0.06818	M1 Sum of 3 reasonable triples or combinations M1 Triples or combinations correct A1 CAO	**3**
(iii)	P(all different) $= 6\times\frac{5}{12}\times\frac{4}{11}\times\frac{3}{10}$ $= \frac{3}{11}$=0.2727	M1 5,4,3 M1 $6\times$ three fractions or $\binom{12}{3}$ denom. A1 CAO	**3**
(iv)	P(all jam given all same) = $\dfrac{\frac{1}{22}}{\frac{3}{44}} = \frac{2}{3}$	M1 Their (i) in numerator M1 Their (ii) in denominator A1 CAO	**3**
(v)	P(all jam exactly twice) $= \binom{5}{2}\times\left(\frac{1}{22}\right)^2\times\left(\frac{21}{22}\right)^3$ = 0.01797	M1 for $\binom{5}{2}$x … M1 for their $p^2\ q^3$ A1 CAO	**3**
(vi)	P(all jam at least once) $=1-\left(\frac{21}{22}\right)^5 = 0.2075$	M1 for their q^5 M1 indep for 1 – 5^{th} power A1 CAO	**3**
		TOTAL	**18**

Mark Scheme 4766
June 2006

Q1 (i)		G1 Labelled linear scales G1 Height of lines	**2**
(ii)	Negative (skewness)	B1	**1**
(iii)	Σfx = 123 so mean = 123/25 = 4.92 o.e. $S_{xx} = 681 - \frac{123^2}{25} = 75.84$ M.s.d = $\frac{75.84}{25} = 3.034$	B1 M1 for S_{xx} attempted A1 FT their 4.92	**3**
(iv)	Total for 25 days is 123 and totals for 31 days is 155. Hence total for next 6 days is 32 and so mean = 5.33	M1 31 x 5 – 25xtheir 4.92 A1 FT their 123	**2**
		TOTAL	**8**
Q2 (i)	$P(A \cap B) = P(A)P(B \mid A) = \frac{7}{10} \times \frac{3}{7}$ $\rightarrow P(A \cap B) = 0.3$ o.e.	M1 Product of these fractions A1	**2**
(ii)		B1FT either 0.4 or 0.2 in correct place B1FT all correct and labelled	**2**
(iii)	P(*B*|*A*) ≠ P(*B*), 3/7 ≠ 0.5 Unequal so not independent	E1 Correct comparison E1*dep* for 'not independent'	**2**
(iv)	3/7 < 0.5 so Isobel is less likely to score when her parents attend	E1 for comparison E1*dep*	**2**
		TOTAL	**8**

Q3 (i)	P(X = 1) = 7k, P(X = 2) = 12k, P(X = 3) = 15k, P(X = 4) = 16k 50k = 1 so k = 1/50	M1 for addition of four multiples of k A1 **ANSWER GIVEN**	**2**
(ii)	E(X) = 1 x 7k + 2 x 12k + 3 x 15k + 4 x 16k = 140k = 2.8 OR E(X) = 1 x $^7/_{50}$ + 2 x $^{12}/_{50}$ + 3 x $^{15}/_{50}$ + 4 x $^{16}/_{50}$ = $^{140}/_{50}$ = 2.8 oe Var(X) = 1 x 7k + 4 x 12k + 9 x 15k + 16 x 16k -7.84 = 1.08 OR Var(X) = 1 x $^7/_{50}$ + 4 x $^{12}/_{50}$ + 9 x $^{15}/_{50}$ + 16 x $^{16}/_{50}$ -7.84 = 8.92 – 7.84 = 1.08	M1 for Σxp (at least 3 terms correct) A1 CAO M1 $\Sigma x^2 p$ (at least 3 terms correct) M1*dep* for – their E(X)² NB provided Var(X) > 0 A1 FT their E(X)	**5**
		TOTAL	**7**
Q4 (i)	4 x 5 x 3 = 60	M1 for 4 x 5 x 3 A1 CAO	**2**
(ii)	**(*A*)** $\binom{4}{2}$ = 6 **(*B*)** $\binom{4}{2}\binom{5}{2}\binom{3}{2}$ = 180	B1 **ANSWER GIVEN** B1 CAO	**2**
(iii)	**(*A*)** 1/5 **(*B*)** $\frac{3}{4}\times\frac{4}{5}\times\frac{2}{3}=\frac{2}{5}$	B1 CAO M1 for $\frac{3}{4}\times\frac{4}{5}\times\frac{2}{3}$ A1	**3**
		TOTAL	**7**
Q5 (i)	$\mathrm{P}(X=2)=\binom{3}{2}\times 0.87^2\times 0.13=0.2952$	M1 0.87^2 x 0.13 M1 $\binom{3}{2}$ x p^2q **with p+q=1** A1 CAO	**3**
(ii)	In 50 throws expect 50 (0.2952) = 14.76 times	B1 FT	**1**
(iii)	P (two 20's twice) = $\binom{4}{2}\times 0.2952^2\times 0.7048^2 = 0.2597$	M1 $0.2952^2\times 0.7048^2$ A1 FT their 0.2952	**2**
		TOTAL	**6**

Q6 **(i)**		G1 for left hand set of branches fully correct including labels and probabilities G1 for right hand set of branches fully correct	**2**
(ii)	P (test is positive) = (0.9)(0.95) + (0.1)(0.2) = 0.875	M1 Two correct pairs added A1 CAO	**2**
(iii)	P (test is correct) = (0.9)(0.95) + (0.1)(0.8) = 0.935	M1 Two correct pairs added A1 CAO	**2**
(iv)	P (Genuine|Positive) = 0.855/0.875 = 0.977	M1 Numerator M1 Denominator A1 CAO	**3**
(v)	P (Fake|Negative) = 0.08/0.125 = 0.64	M1 Numerator M1 Denominator A1 CAO	**3**
(vi)	EITHER: A positive test means that the painting is almost certain to be genuine so no need for a further test. However, more than a third of those paintings with a negative result are genuine so a further test is needed. NOTE: Allow sensible alternative answers	E1FT E1FT	**2**
(vii)	P (all 3 genuine) = $(0.9 \times 0.05 \times 0.96)^3$ $= (0.045 \times 0.96)^3$ $= (0.0432)^3$ = 0.0000806	M1 for 0.9 x 0.05 (=0.045) M1 for complete correct triple product M1*indep* for cubing A1 CAO	**4**
		TOTAL	**18**

Q7 (i)	$X \sim B(20, 0.1)$ **(A)** $P(X=1) = \binom{20}{1} \times 0.1 \times 0.9^{19} = 0.2702$ OR from tables $0.3917 - 0.1216 = 0.2701$	M1 0.1×0.9^{19} M1 $\binom{20}{1} \times pq^{19}$ A1 CAO OR: M2 for 0.3917 – 0.1216 A1 CAO	**3**
	(B) $P(X \geq 1) = 1 - 0.1216 = 0.8784$	M1 P(X=0) *provided that P(X≥1)=1–P(X≤1) not seen* M1 1-P(X=0) A1 CAO	**3**
(ii)	EITHER: $1 - 0.9^n \geq 0.8$ $0.9^n \leq 0.2$ Minimum $n = 16$ OR (using trial and improvement): Trial with 0.9^{15} or 0.9^{16} or 0.9^{17} $1 - 0.9^{15} = 0.7941 < 0.8$ and $1 - 0.9^{16} = 0.8147 > 0.8$ Minimum $n = 16$ NOTE: $n = 16$ unsupported scores SC1 only	M1 for 0.9^n M1 for inequality A1 CAO M1 M1 A1 CAO	**3**
(iii)	**(A)** Let p = probability of a randomly selected rock containing a fossil (for population) H_0: $p = 0.1$ H_1: $p < 0.1$	B1 for definition of p B1 for H_0 B1 for H_1	**3**
	(B) Let $X \sim B(30, 0.1)$ $P(X \leq 0) = 0.0424 < 5\%$ $P(X \leq 1) = 0.0424 + 0.1413 = 0.1837 > 5\%$ So critical region consists only of 0.	M1 for attempt to find $P(X \leq 0)$ or $P(X \leq 1)$ using binomial M1 for both attempted M1 for comparison of either of the above with 5% A1 for critical region dep on both comparisons **(NB Answer given)**	**4**
	(C) 2 does not lie in the critical region. So there is insufficient evidence to reject the null hypothesis and we conclude that it seems that 10% of rocks in this area contain fossils.	M1 for comparison A1 for conclusion **in context**	**2**
		TOTAL	**18**

Mark Scheme 4766
January 2007

GENERAL INSTRUCTIONS

Marks in the mark scheme are explicitly designated as **M**, **A**, **B**, **E** or **G**.

M marks ("method") are for an attempt to use a correct method (not merely for stating the method).

A marks ("accuracy") are for accurate answers and can only be earned if corresponding **M** mark(s) have been earned. Candidates are expected to give answers to a sensible level of accuracy in the context of the problem in hand. The level of accuracy quoted in the mark scheme will sometimes deliberately be greater than is required, when this facilitates marking.

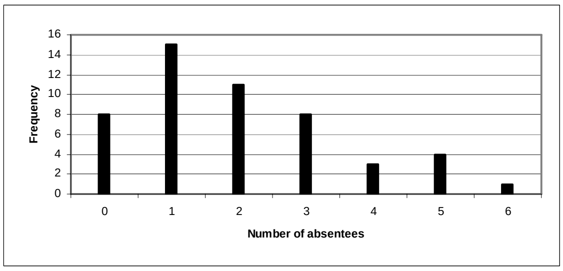
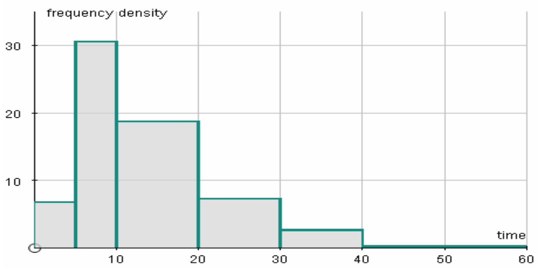
B marks are independent of all others. They are usually awarded for a single correct answer.

E marks ("explanation") are for explanation and/or interpretation. These will frequently be sub divisible depending on the thoroughness of the candidate's answer.

G marks ("graph") are for completing a graph or diagram correctly.

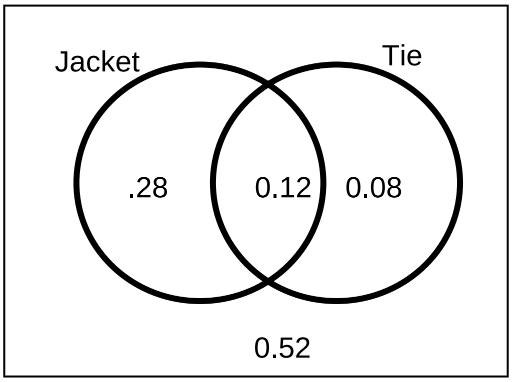
- Insert part marks in **right-hand** margin in line with the mark scheme. For fully correct parts tick the answer. For partially complete parts indicate clearly in the body of the script where the marks have been gained or lost, in line with the mark scheme.
- Please indicate incorrect working by ringing or underlining as appropriate.
- Insert total in **right-hand** margin, ringed, at end of question, in line with the mark scheme.
- Numerical answers which are not exact should be given to at least the accuracy shown. Approximate answers to a greater accuracy *may* be condoned.
- Probabilities should be given as fractions, decimals or percentages.
- FOLLOW-THROUGH MARKING SHOULD NORMALLY BE USED WHEREVER POSSIBLE. There will, however, be an occasional designation of '**c.a.o.**' for "correct answer only".
- Full credit MUST be given when correct alternative methods of solution are used. If errors occur in such methods, the marks awarded should correspond as nearly as possible to equivalent work using the method in the mark scheme.
- The following notation should be used where applicable:

FT	Follow-through marking
BOD	Benefit of doubt
ISW	Ignore subsequent working

Q 1 (i)	Mean = 127.6/13 = 9.8 Median = 8.6 Midrange = 14.5	M1 for 127.6/13 soi A1 CAO B1 CAO B1 CAO	**4**
(ii)	Mean slightly inflated due to the outlier Median good since it is not affected by the outlier Midrange poor as it is highly inflated due to the outlier	B1 B1 B1	**3**
		TOTAL	**7**
Q 2 (i)		G1 labelled linear scales on both axes G1 heights	**2**
(ii)	Mean $= \frac{99}{50} = 1.98$ $S_{xx} = 315 - \frac{99^2}{50}$ (= 118.98) *rmsd* $= \sqrt{\frac{118.98}{50}} = 1.54$ *NB full marks for correct results from recommended method which is use of calculator functions*	B1 for mean M1 for attempt at S_{xx} A1 CAO	**3**
(iii)	New mean = 30 – 1.98 = 28.02 New rmsd = 1.54 (unchanged)	B1 FT their mean B1 FT their rmsd	**2**
		TOTAL	**7**
Q 3 (i)	time / freq / width / f dens 0- / 34 / 5 / 6.8 5- / 153 / 5 / 30.6 10- / 188 / 10 / 18.8 20- / 73 / 10 / 7.3 30- / 27 / 10 / 2.7 40- / 5 / 20 / 0.25 	M1 for fds A1 CAO Accept any suitable unit for fd such as eg freq per 5 mins. G1 linear scales on both axes and label G1 width of bars G1 height of bars	**5**
(ii)	Positive skewness	B1 CAO (indep)	**1**
		TOTAL	**6**

<table>
<tr><td>Q 4(i)</td><td>
<table>
<tr><td>r</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>P(X = r)</td><td>k</td><td>3k</td><td>5k</td><td>7k</td><td>9k</td><td>11k</td></tr>
</table>
$36k = 1$, so $k = \frac{1}{36}$</td><td>B1 for 3k, 5k, 7k, 9k

M1 for sum of six multiples of k = 1

A1 CAO MUST BE FRACTION IN SIMPLEST FORM</td><td>3</td></tr>
<tr><td>(ii)</td><td>E(X) =
$1\times\frac{1}{36}+2\times\frac{3}{36}+3\times\frac{5}{36}+4\times\frac{7}{36}+5\times\frac{9}{36}+6\times\frac{11}{36}=\frac{161}{36}=4.47$</td><td>M1 for $\Sigma\, rp$
A1 CAO</td><td>2</td></tr>
<tr><td>(iii)</td><td>P(X=16) = $6\times\left(\frac{1}{6}\right)^3$
$=\frac{6}{216}=\frac{1}{36}$</td><td>M1 for 6 ×
M1 indep for $\left(\frac{1}{6}\right)^3$
A1 CAO</td><td>3</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>8</td></tr>
<tr><td>Q 5(i)</td><td>P(jacket and tie) = 0.4 × 0.3 = 0.12</td><td>M1 for multiplying
A1 CAO</td><td>2</td></tr>
<tr><td>(ii)</td><td>
</td><td>G1 for two intersecting circles labelled

G1 for 0.12 and either 0.28 or 0.08

G1 for remaining probabilities

<u>Note</u> FT their 0.12 provided < 0.2</td><td>3</td></tr>
<tr><td>(iii)</td><td>(A) P(jacket or tie) =P(J) + P(T) – P(J∩T)
= 0.4 + 0.2 – 0.12 = 0.48
OR = 0.28 + 0.12 + 0.08 = 0.48

(B) P(no jacket or no tie) = 0.52 + 0.28 + 0.08 = 0.88
OR 0.6 + 0.8 – 0.52 = 0.88
OR 1 – 0.12 = 0.88</td><td>B1 FT

B2 FT
<u>Note</u> FT their 0.12 provided < 0.2</td><td>3</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>8</td></tr>
</table>

Q 6 (i)	Median = 3370 $Q_1 = 3050 \quad Q_3 = 3700$ Inter-quartile range = 3700 – 3050 = 650	B1 B1 for Q_3 or Q_1 B1 for IQR	**3**
(ii)	Lower limit $3050 - 1.5 \times 650 = 2075$ Upper limit $3700 + 1.5 \times 650 = 4675$ Approx 40 babies below 2075 and 5 above 4675 so total 45	B1 B1 M1 (for either) A1	**4**
(iii)	Decision based on convincing argument: eg 'no, because there is nothing to suggest that they are not genuine data items and these data may influence health care provision'	E2 for convincing argument	**2**
(iv)	All babies below 2600 grams in weight	B2 CAO	**2**
(v)	(*A*) $X \sim B(17, 0.12)$ $P(X = 2) = \binom{17}{2} \times 0.12^2 \times 0.88^{15} = 0.2878$ (*B*) $P(X > 2)$ $= 1 - \left(0.2878 + \binom{17}{1} \times 0.12 \times 0.88^{16} + 0.88^{17}\right)$ $= 1 - (0.2878 + 0.2638 + 0.1138) = 0.335$	M1 $\binom{17}{2} \times p^2 \times q^{15}$ M1 indep $0.12^2 \times 0.88^{15}$ A1 CAO M1 for $P(X=1) + P(X=0)$ M1 for $1 - P(X \leq 2)$ A1 CAO	**3** **3**
(vi)	Expected number of occasions is 33.5	B1 FT	**1**
		TOTAL	**18**

Q 7 (i)	(*A*) P(both) = $\left(\frac{2}{3}\right)^2 = \frac{4}{9}$ (*B*) P(one) = $2\times\frac{2}{3}\times\frac{1}{3}=\frac{4}{9}$ (*C*) P(neither) = $\left(\frac{1}{3}\right)^2 = \frac{1}{9}$	B1 CAO B1 CAO B1 CAO	**3**
(ii)	Independence necessary because otherwise, the probability of one seed germinating would change according to whether or not the other one germinates. May not be valid as the two seeds would have similar growing conditions eg temperature, moisture, etc. *NB Allow valid alternatives*	E1 E1	**2**
(iii)	Expected number = 2 × $\frac{2}{3}=\frac{4}{3}$ (= 1.33) E(X^2) = $0\times\frac{1}{9}+1\times\frac{4}{9}+4\times\frac{4}{9}=\frac{20}{9}$ Var(X) = $\frac{20}{9}-\left(\frac{4}{3}\right)^2=\frac{4}{9}$ = 0.444 *NB use of npq scores M1 for product, A1CAO*	B1 FT M1 for E(X^2) A1 CAO	**3**
(iv)	Expect $200\times\frac{8}{9}=177.8$ plants So expect 0.85 × 177.8 = 151 onions	M1 for 200 × $\frac{8}{9}$ M1 dep for × 0.85 A1 CAO	**3**
(v)	Let X ~ B(18, p) Let p = probability of germination (for population) H_0: p = 0.90 H_1: p < 0.90 P($X \le 14$) = 0.0982 > 5% So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the germination rate is below 90%. Note: use of critical region method scores M1 for region {0,1,2,…, 13} M1 for 14 does not lie in critical region then A1 E1 as per scheme	B1 for definition of p B1 for H_0 B1 for H_1 M1 for probability M1 dep for comparison A1 E1 for conclusion in context	**7**
		TOTAL	**18**

Mark Scheme 4766
June 2007

<table>
<tr><td>Q1 (i)</td><td>$\binom{8}{4}$ ways to select $= 70$</td><td>M1 for $\binom{8}{4}$
A1 CAO</td><td>2</td></tr>
<tr><td>(ii)</td><td>$4! = 24$</td><td>B1 CAO</td><td>1</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>3</td></tr>
<tr><td>Q2
(i)</td><td><table><tr><td>Amount</td><td>0- <20</td><td>20- <50</td><td>50- <100</td><td>100- <200</td></tr><tr><td>Frequency</td><td>800</td><td>480</td><td>400</td><td>200</td></tr></table></td><td>B1 for amounts

B1 for frequencies</td><td>2</td></tr>
<tr><td>(ii)</td><td>Total ≈
$10\times800+35\times480+75\times400+150\times200=£84800$</td><td>M1 for their midpoints × their frequencies
A1 CAO</td><td>2</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>4</td></tr>
<tr><td>Q3 (i)</td><td>Mean $= \dfrac{3026}{56} = 54.0$

$S_{xx} = 178890 - \dfrac{3026^2}{56} = 15378$

$s = \sqrt{\dfrac{15378}{55}} = 16.7$</td><td>B1 for mean

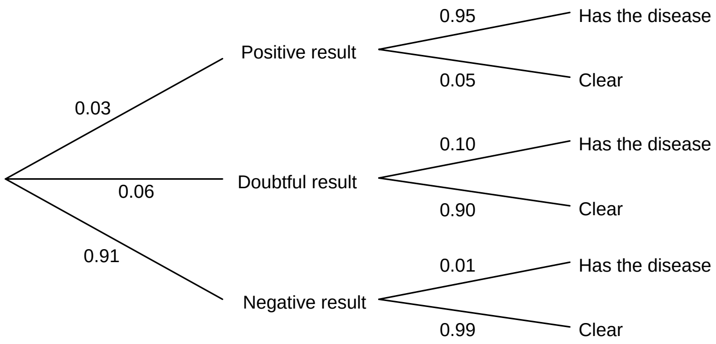
M1 for attempt at S_{xx}

A1 CAO</td><td>3</td></tr>
<tr><td>(ii)</td><td>$\bar{x} + 2s = 54.0 + 2\times16.7 = 87.4$
So 93 is an outlier</td><td>M1 for their $\bar{x}$ +2×their s
A1 FT for 87.4 and comment</td><td>2</td></tr>
<tr><td>(iii)</td><td>New mean = $1.2\times54.0 - 10 = 54.8$
New $s = 1.2\times16.7 = 20.1$</td><td>B1 FT
M1A1 FT</td><td>3</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>8</td></tr>
<tr><td>Q4
(i)</td><td>(A) P(at least one) $= \dfrac{36}{50} = \dfrac{18}{25} = 0.72$

(B) P(exactly one) $= \dfrac{9+6+5}{50} = \dfrac{20}{50} = \dfrac{2}{5} = 0.4$</td><td>B1 aef

M1 for (9+6+5)/50
A1 aef</td><td>3</td></tr>
<tr><td>(ii)</td><td>P(not paper | aluminium) $= \dfrac{13}{24}$</td><td>M1 for denominator 24 or 24/50 or 0.48
A1 CAO</td><td>2</td></tr>
<tr><td>(iii)</td><td>P(one kitchen waste) $= 2\times\dfrac{18}{50}\times\dfrac{32}{49} = \dfrac{576}{1225} = 0.470$</td><td>M1 for both fractions
M1 for 2 × product of both, or sum of 2 pairs
A1</td><td>3</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>8</td></tr>
</table>

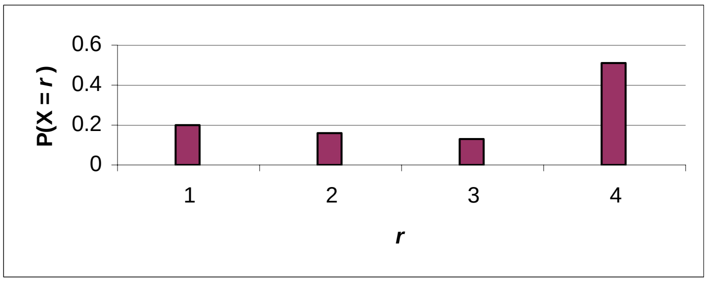
Q5 (i)	11th value is 4,12th value is 4 so median is 4 Interquartile range = 5 – 2 = 3	B1 M1 for either quartile A1 CAO	**3**
(ii)	No, not valid any two valid reasons such as : • the sample is only for two years, which may not be representative • the data only refer to the local area, not the whole of Britain • even if decreasing it may have nothing to do with global warming • more days with rain does not imply more total rainfall • a five year timescale may not be enough to show a long term trend	B1 E1 E1	**3**
		TOTAL	**6**
Q6 (i)	Either P(all 4 correct) = $\frac{4}{7}\times\frac{3}{6}\times\frac{2}{5}\times\frac{1}{4}=\frac{1}{35}$ or P(all 4 correct) = $\frac{1}{{}^7\boldsymbol{C}_4}=\frac{1}{35}$	M1 for fractions, or ${}^7C_4$ seen A1 **NB answer given**	**2**
(ii)	$E(X) = 1\times\frac{4}{35}+2\times\frac{18}{35}+3\times\frac{12}{35}+4\times\frac{1}{35}=\frac{80}{35}=2\frac{2}{7}=2.29$ $E(X^2) = 1\times\frac{4}{35}+4\times\frac{18}{35}+9\times\frac{12}{35}+16\times\frac{1}{35}=\frac{200}{35}=5.714$ $\text{Var}(X) = \frac{200}{35}-\left(\frac{80}{35}\right)^2=\frac{24}{49}$ = 0.490 (to 3 s.f.)	M1 for Σrp (at least 3 terms correct) A1 CAO M1 for Σx^2p (at least 3 terms correct) M1*dep* for – their E(X)² A1 FT their E(X) provided Var(X) > 0	**5**
		TOTAL	**7**

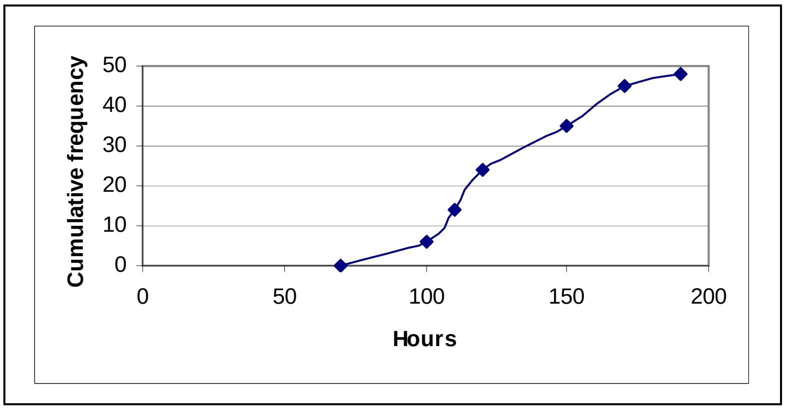
	Section B		
Q7 (i)		G1 probabilities of result G1 probabilities of disease G1 probabilities of clear G1 labels	**4**
(ii)	P(negative and clear) $= 0.91 \times 0.99$ $= 0.9009$	M1 for their 0.91×0.99 A1 CAO	**2**
(iii)	P(has disease) $= 0.03 \times 0.95 + 0.06 \times 0.10 + 0.91 \times 0.01$ $= 0.0285 + 0.006 + 0.0091$ $= 0.0436$	M1 three products M1*dep* sum of three products A1 FT their tree	**3**
(iv)	P(negative | has disease) $= \dfrac{\text{P(negative } \textit{and} \text{ has disease)}}{\text{P(has disease)}} = \dfrac{0.0091}{0.0436} = 0.2087$	M1 for their 0.01×0.91 or 0.0091 on its own or as numerator M1 *indep* for their 0.0436 as denominator A1 FT their tree	**3**
(v)	Thus the test result is not very reliable. A relatively large proportion of people who have the disease will test negative.	E1 FT for idea of 'not reliable' or 'could be improved', etc E1 FT	**2**
(vi)	P(negative or doubtful and declared clear) $= 0.91 + 0.06 \times 0.10 \times 0.02 + 0.06 \times 0.90 \times 1$ $= 0.91 + 0.00012 + 0.054 = 0.96412$	M1 for their 0.91 + M1 for either triplet M1 for second triplet A1 CAO	**4**
		TOTAL	**18**

Q8 (i)	$X \sim B(17, 0.2)$ $P(X \geq 4) = 1 - P(X \leq 3)$ $= 1 - 0.5489 = 0.4511$	B1 for 0.5489 M1 for 1 – their 0.5489 A1 CAO	**3**
(ii)	$E(X) = np = 17 \times 0.2 = 3.4$	M1 for product A1 CAO	**2**
(iii)	$P(X = 2) = 0.3096 - 0.1182 = 0.1914$ $P(X = 3) = 0.5489 - 0.3096 = 0.2393$ $P(X = 4) = 0.7582 - 0.5489 = 0.2093$ So 3 applicants is most likely	B1 for 0.2393 B1 for 0.2093 A1 CAO *dep* on both B1s	**3**
(iv)	(*A*) Let p = probability of a randomly selected maths graduate applicant being successful (for population) H_0: $p = 0.2$ H_1: $p > 0.2$ (*B*) H_1 has this form as the suggestion is that mathematics graduates are <u>more</u> likely to be successful.	B1 for definition of p in context B1 for H_0 B1 for H_1 E1	**4**
(v)	Let $X \sim B(17, 0.2)$ $P(X \geq 6) = 1 - P(X \leq 5) = 1 - 0.8943 = 0.1057 > 5\%$ $P(X \geq 7) = 1 - P(X \leq 6) = 1 - 0.9623 = 0.0377 < 5\%$ So critical region is {7,8,9,10,11,12,13,14,15,16,17}	B1 for 0.1057 B1 for 0.0377 M1 for at least one comparison with 5% A1 CAO for critical region *dep* on M1 and at least one B1	**4**
(vi)	Because $P(X \geq 6) = 0.1057 > 10\%$ Either: comment that 6 is still outside the critical region Or comparison $P(X \geq 7) = 0.0377 < 10\%$	E1 E1	**2**
		TOTAL	**18**

4766 Statistics 1

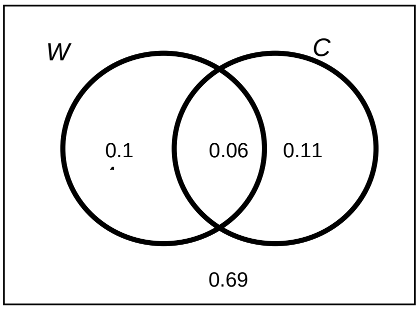
Q1 (i)	Mode = 7 Median = 12.5	B1 **cao** B1 **cao**	**2**
(ii)	Positive or positively skewed	E1	**1**
(iii)	(*A*) Median (*B*) There is a large outlier or possible outlier of 58 / figure of 58. Just 'outlier' on its own without reference to either 58 or large scores E0 Accept the large outlier affects the mean (more) E1	E1 cao E1indep	**2**
(iv)	There are $14.75 \times 28 = 413$ messages So total cost = 413×10 pence = £41.30	M1 for 14.75×28 but 413 can also imply the mark A1**cao**	**2**
		TOTAL	**7**
Q2 (i)	$\binom{4}{3} \times 3! = 4 \times 6 = 24$ codes or ${}^4P_3 = 24$ (M2 for ${}^4P_3$) *Or* $4 \times 3 \times 2 = 24$	M1 for 4 M1 for $\times 6$ A1	**3**
(ii)	$4^3 = 64$ codes	M1 for 4^3 A1 **cao**	**2**
		TOTAL	**5**
Q3 (i)	Probability = $0.3 \times 0.8 = 0.24$	M1 for 0.8 from (1-0.2) A1	**2**
(ii)	*Either:* $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ $= 0.3 + 0.2 - 0.3 \times 0.2$ $= 0.5 - 0.06 = 0.44$ *Or:* $P(A \cup B) = 0.7 \times 0.2 + 0.3 \times 0.8 + 0.3 \times 0.2$ $= 0.14 + 0.24 + 0.06 = 0.44$ *Or:* $P(A \cup B) = 1 - P(A' \cap B')$ $= 1 - 0.7 \times 0.8 = 1 - 0.56 = 0.44$	M1 for adding 0.3 and 0.2 M1 for **subtraction** of (0.3×0.2) A1 **cao** M1 either of first terms M1 for last term A1 M1 for 0.7×0.8 or 0.56 M1 for complete method as seen A1	**3**
(iii)	$P(A\|B) = \dfrac{P(A \cap B)}{P(B)} = \dfrac{0.06}{0.44} = \dfrac{6}{44} = 0.136$	M1 for numerator of their 0.06 only M1 for 'their 0.44' in denominator A1 FT (must be valid p)	**3**
		TOTAL	**8**

Q4 (i)	$E(X) = 1\times0.2 + 2\times0.16 + 3\times0.128 + 4\times0.512 = 2.952$ Division by 4 or other spurious value at end loses A mark $E(X^2) = 1\times0.2 + 4\times0.16 + 9\times0.128 + 16\times0.512 = 10.184$ $\mathrm{Var}(X) = 10.184 - 2.952^2 = 1.47$ (to 3 s.f.)	M1 for $\Sigma\, rp$ (at least 3 terms correct) A1 cao M1 for $\Sigma\, x^2p$ *at least 3 terms correct* M1 for $E(X^2) - E(X)^2$ Provided ans > 0 A1 FT their $E(X)$ but not a wrong $E(X^2)$	**5**
(ii)	Expected cost = 2.952 × £45000 = £133000 (3sf)	B1 FT (no extra multiples / divisors introduced at this stage)	**1**
(iii)		G1 labelled linear scales G1 height of lines	**2**
		TOTAL	**8**
Q5 (i)	Impossible because the competition would have finished as soon as Sophie had won the first 2 matches	E1	**1**
(ii)	**SS, JSS, JSJSS**	B1, B1, B1 (-1 each error or omission)	**3**
(iii)	$0.7^2 + 0.3 \times 0.7^2 + 0.7 \times 0.3 \times 0.7^2 = 0.7399$ or $0.74(0)$ { 0.49 + 0.147 + 0.1029 = 0.7399}	M1 for any correct term M1 for any other correct term M1 for sum of all three correct terms A1 cao	**4**
		TOTAL	**8**

	Section B		
Q6 (i)	Mean = $\frac{180.6}{12}$ = 15.05 or 15.1 S_{xx} = $3107.56 - \frac{180.6^2}{12}$ or 3107.56 – 12(their 15.05)^2 **=** (389.53) $s = \sqrt{\frac{389.53}{11}}$ = 5.95 or better NB Accept answers seen without working (from calculator)	B1 for mean M1 for attempt at S_{xx} A1 cao	**3**
(ii)	$\bar{x}$ + 2s = 15.05 + 2 × 5.95 = 26.95 $\bar{x}$ – 2s = 15.05 – 2 × 5.95 = 3.15 So no outliers	M1 for attempt at either M1 for both A1 for limits and conclusion FT their mean and sd	**3**
(iii)	New mean = 1.8 × 15.05 + 32 = 59.1 New s = 1.8 × 5.95 = 10.7	B1FT M1 A1FT	**3**
(iv)	New York has a higher mean or ' is on average' higher (oe) New York has greater spread /range /variation or SD (oe)	E1FT using ^{0}F ($\bar{x}$ dep) E1FT using ^{0}F (σ dep)	**2**
(v)	Upper bound: (70), 100, 110, 120, 150, 170, 190 Cumulative frequency: (0), 6, 14, 24, 35, 45, 48  NB all G marks dep on attempt at cumulative frequencies.	B1 for all **correct** cumulative frequencies (may be implied from graph). **Ignore cf of 0 at this stage** G1 for linear scales (linear from 70 to 190) ignore x < 70 vertical: 0 to 50 but not beyond 100 (no inequality scales) G1 for labels G1 for points plotted as (UCB, their cf). Ignore (70,0) at this stage. **No** mid – point or LCB plots**.** G1 for joining all of 'their points'(line or smooth curve) **AND now including (70,0)**	**5**
(vi)	NB All G marks dep on attempt at cumulative frequencies Line on graph at cf = 43.2(soi) or used 90th percentile = 166	M1 for use of 43.2 A1FT but **dep on 3rd G mark earned**	**2**
		TOTAL	**18**

Q7 **(i)**	$X \sim B(12, 0.05)$ **(A)** $P(X = 1) = \binom{12}{1} \times 0.05 \times 0.95^{11} = 0.3413$ OR from tables $0.8816 - 0.5404 = 0.3412$ **(B)** $P(X \geq 2) = 1 - 0.8816 = 0.1184$ **(C)** Expected number $E(X) = np = 12 \times 0.05 = 0.6$	M1 0.05×0.95^{11} M1 $\binom{12}{1} \times pq^{11}$ (p+q) = 1 A1 cao OR: M1 for 0.8816 seen and M1 for subtraction of 0.5404 A1 cao M1 for 1 – P(X ≤ 1) A1 cao M1 for 12×0.05 A1 cao (= 0.6 seen)	**3** **2** **2**
(ii)	*Either*: $1 - 0.95^n \leq ⅓$ $0.95^n \geq ⅔$ $n \leq \log ⅔ / \log 0.95$, so $n \leq 7.90$ Maximum $n = 7$ *Or:* (using tables with $p = 0.05$): $n = 7$ leads to $P(X \geq 1) = 1 - P(X = 0) = 1 - 0.6983 = 0.3017$ (< ⅓) or 0.6983 (> 2/3) $n = 8$ leads to $P(X \geq 1) = 1 - P(X = 0) = 1 - 0.6634 = 0.3366$ (> ⅓) or 0.6634 (< 2/3) Maximum $n = 7$ (total accuracy needed for tables) *Or:* (using trial and improvement): $1 - 0.95^7 = 0.3017$ (< ⅓) or $0.95^7 = 0.6983$ (> 2/3) $1 - 0.95^8 = 0.3366$ (> ⅓) or $0.96^8 = 0.6634$ (< 2/3) Maximum $n = 7$ (3 sf accuracy for calculations) NOTE: $n = 7$ unsupported scores SC1 only	M1 for equation in n M1 for use of logs A1 cao M1indep M1indep A1 cao dep on both M's M1indep (as above) M1indep (as above) A1 cao dep on both M's	 **3**
(iii)	Let $X \sim B(60, p)$ Let p = probability of a bag being faulty H_0: $p = 0.05$ H_1: $p < 0.05$ $P(X \leq 1) = 0.95^{60} + 60 \times 0.05 \times 0.95^{59} = 0.1916 > 10\%$ So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the new process reduces the failure rate or scientist incorrect/ wrong.	B1 for definition of p B1 for H_0 B1 for H_1 M1 A1 for probability M1 for comparison A1 E1	**8**
		TOTAL	**18**

4766 Statistics 1

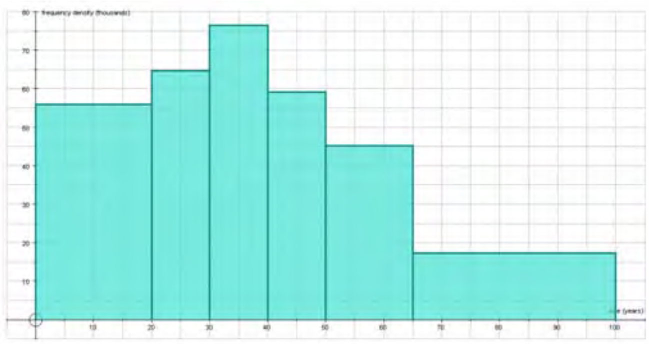
Q1 (i)	Mean = 7.35 (or better) Standard deviation: 3.69 – 3.70 (awfw) Allow s^2 = 13.62 to 13.68 Allow rmsd = 3.64 – 3.66 (awfw) **After B0, B0 scored** then if at least 4 correct mid-points seen or used.**{1.5, 4, 6, 8.5, 15}** Attempt of their mean = $\frac{\sum fx}{\mathbf{44}}$, with $301 \le fx \le 346$ and fx strictly from mid-points not class widths or top/lower boundaries.	B2cao $\sum fx$ = 323.5 B2cao $\sum fx^2$ = 2964.25 (B1) for variance s.o.i.o (B1) for rmsd (B1) mid-points (B1) $6.84 \le \text{mean} \le 7.86$	**4**
(ii)	Upper limit = 7.35 + 2 × 3.69 = 14.73 or 'their sensible mean' + 2 × 'their sensible s.d.' So there could be one or more outliers	M1 (with s.d. < mean) E1**dep** on B2, B2 earned and comment	**2**
		TOTAL	**6**
Q2 (i)	$P(W) \times P(C) = 0.20 \times 0.17 = 0.034$ $P(W \cap C) = 0.06$ (given in the question) Not equal so not independent (Allow $0.20 \times 0.17 \neq 0.06$ or $\neq$ p $(W \cap C)$ so not independent).	M1 for multiplying or 0.034 seen A1 (numerical justification needed)	**2**
(ii)	 The last two G marks are independent of the labels	G1 for two **overlapping** circles labelled G1 for 0.06 and either 0.14 or 0.11 in the **correct places** G1 for all 4 **correct** probs in the **correct** places **(including the 0.69)** NB No credit for Karnaugh maps here	**3**
(iii)	$P(W \mid C) = \frac{P(W \cap C)}{P(C)} = \frac{0.06}{0.17} = \frac{6}{17} = 0.353$ (awrt 0.35)	M1 for 0.06 / 0.17 A1 cao	**2**

(iv)	Children are more likely than adults to be able to speak Welsh or 'proportionally more children speak Welsh than adults' Do not accept: **'**more Welsh children speak Welsh than adults'	E1FT Once the correct idea is seen, apply ISW	**1**
		TOTAL	**8**
Q3 (i)	$(\boldsymbol{A})$ $0.5 + 0.35 + \boldsymbol{p} + \boldsymbol{q} = 1$ so $\boldsymbol{p} + \boldsymbol{q} = 0.15$ $(\boldsymbol{B})$ $0 \times 0.5 + 1 \times 0.35 + 2\boldsymbol{p} + 3\boldsymbol{q} = 0.67$ so $2\boldsymbol{p} + 3\boldsymbol{q} = 0.32$ $(\boldsymbol{C})$ from above $2\boldsymbol{p} + 2\boldsymbol{q} = 0.30$ so $\boldsymbol{q} = 0.02, \boldsymbol{p} = 0.13$	B1 p + q in a correct equation before they reach p + q =0.15 B1 2p + 3q in a correct equation before they reach 2p + 3q = 0.32 (B1) for any 1 correct answer B2 for both correct answers	**1** **1** **2**
(ii)	E(X^2) = $0 \times 0.5 + 1 \times 0.35 + 4 \times 0.13 + 9 \times 0.02 = 1.05$ Var(X) = 'their 1.05' – 0.67^2 = 0.6011 (awrt 0.6) (M1, M1 can be earned with their p^+ and q^+ but not A mark)	M1 $\Sigma x^2 p$ (at least 2 non zero terms correct) M1dep for (– 0.67^2), provided Var(X) > 0 A1 cao (No n or n-1 divisors)	**3**
		TOTAL	**7**
Q4 (i)	$X \sim$ B(8, 0.05) $(\boldsymbol{A})$ $\mathrm{P}(\boldsymbol{X} = 0) = 0.95^8 = 0.6634$ 0.663 or better *Or* using tables $\mathrm{P}(\boldsymbol{X} = 0) = 0.6634$ $(\boldsymbol{B})$ $\mathrm{P}(\boldsymbol{X} = 1) = \binom{8}{1} \times 0.05 \times 0.95^7 = 0.2793$ $\mathrm{P}(\boldsymbol{X} > 1) = 1 - (0.6634 + 0.2793) = 0.0573$ *Or* using tables P(X > 1) = 1 – 0.9428 = 0.0572	M1 0.95^8 A1 CAO Or B2 (tables) M1 for P(X = 1)(allow 0.28 or better) M1 for 1 – P(X ≤ 1) must have both probabilities A1cao (0.0572 – 0.0573) M1 for P(X ≤ 1) 0.9428 M1 for 1 – P(X ≤ 1) A1 cao (must end in…2)	**2** **3**
(ii)	Expected number of days = 250 × 0.0572 = 14.3 awrt	M1 for 250 x prob(B) A1 FT but no rounding at end	**2**
		TOTAL	**7**

Q5 (i)	Let p = probability of remembering or naming all items (for population) (whilst listening to music.) H_0: $p = 0.35$ H_1: $p > 0.35$ H_1 has this form since the student believes that the probability will be increased/ improved/ got better /gone up.	B1 for definition of p B1 for H_0 B1 for H_1 E1dep on p>0.35 in H_0 In words not just because p > 0.35	**4**
(ii)	Let $X \sim B(15, 0.35)$ ***Either***: $P(X \geq 8) = 1 - 0.8868 = 0.1132 > 5\%$ Or 0.8868 < 95% So not enough evidence to reject H_0 (Accept H_o) Conclude that there is not enough evidence to indicate that the probability of remembering all of the items is improved / improved/ got better /gone up. (when listening to music.) --- ***Or***: Critical region for the test is {9,10,11,12,13,14,15} 8 does not lie in the critical region. So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the probability of remembering all of the items is improved / improved/ got better /gone up. (when listening to music.) --- ***Or***: The smallest critical region that 8 could fall into is {8, 9, 10, 11, 12, 13, 14, and 15}. The size of this region is 0.1132 0.1132 > 5% So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the probability of remembering all of the items is improved (when listening to music)	***Either:*** M1 for probability (0.1132) M1**dep** for comparison A1**dep** E1**dep on all previous marks** for conclusion in **context** ----------------------------- ***Or***: M1 for correct CR(no omissions or additions) M1**dep** for 8 does not lie in CR A1**dep** E1**dep on all previous marks** for conclusion in **context** **-----------------------------** **Or**: M1 for CR{8,9,…15}**and** size = 0.1132 M1 **dep** for comparison A1**dep** E1**dep on all previous marks** for conclusion in **context**	**4**
		TOTAL	**8**

	Section B		
Q6 (i)	(*A*) P(both rest of UK) = 0.20×0.20 = 0.04	M1 for multiplying A1cao	**2**
	(*B*) *Either:* **All 5 case** P(at least one England) = (0.79 x 0.20) + (0.79 x 0.01) + (0.20 x 0.79) + (0.01 x 0.79) + (0.79 x 0.79) = 0.158 + 0.0079 + 0.158 + 0.0079 + 0.6241 = 0.9559 *Or* P(at least one England) = 1 – P(neither England) = 1 – (0.21×0.21) = 1 – 0.0441 = 0.9559 or listing all = 1 –{ (0.2 x 0.2) + (0.2 x 0.01) + (0.01 x 0.20) + (0.01x 0.01)} = 1 – (**) = 1 – { 0.04 + 0.002 + 0.002 + 0.0001) = 1 – 0.0441 = 0.9559 Or: **All 3 case** P(at least one England) = = $0.79 \times 0.21 + 0.21 \times 0.79 + 0.79^2$ = 0.1659 + 0.1659 + 0.6241 = 0.9559	M1 for any correct term (3case or 5case) M1 for correct sum of all 3 (or of all 5) with **no extras** A1cao (condone 0.96 www) *Or* M1 for 0.21×0.21 or for (**) fully enumerated or 0.0441 seen M1**dep** for 1 – (1st part) A1cao See above for 3 case	**3**
	(*C*)*Either* 0.79 x 0.79 + 0.79 x 0.2 + 0.2 x 0.79 + 0.2 x 0.2 = 0.9801 *Or* 0.99×0.99 = 0.9801 Or 1 – { 0.79 x 0.01 + 0.2 x 0.01 + 0.01 x 0.79 + 0.01 x 0.02 + 0.01^2 } = 1 – 0.0199 = 0.9801	M1 for sight of all 4 correct terms summed A1 cao (condone 0.98 www) *or* M1 for 0.99 x 0.99 A1cao ***Or*** M1 for everything 1 – {…..} A1cao	**2**
(ii)	P(both the rest of the UK | neither overseas) $= \frac{\text{P(the rest of the UK } \textit{and} \text{ neither overseas)}}{\text{P(neither overseas)}}$ $= \frac{0.04}{0.9801} = 0.0408$ {Watch for: $\frac{answer(A)}{answer(C)}$ as evidence of method (p <1)}	M1 for numerator of 0.04 or 'their answer to (i)(A)' M1 for denominator of 0.9801 or 'their answer to (i) (C)' A1 FT (0 < p < 1) 0.041 at least	**3**

(iii)	(A) Probability = $1 - 0.79^5$ $= 1 - 0.3077$ $= 0.6923$ (accept awrt 0.69) see additional notes for alternative solution	M1 for 0.79^5 or 0.3077... M1 for $1 - 0.79^5$ dep A1 CAO	
	(B) $1 - 0.79^n > 0.9$ **EITHER:** $1 - 0.79^n > 0.9$ or $0.79^n < 0.1$ (condone = and $\geq$ throughout) but not reverse inequality n > $\frac{\log \mathbf{0.1}}{\log \mathbf{0.79}}$, so n > 9.768… Minimum n = 10 Accept n $\geq$ 10	M1 for equation/inequality in n (accept either statement opposite) M1(indep) for process of using logs i.e. $\frac{\log a}{\log b}$ A1 CAO	3
	--- **OR** (using trial and improvement): Trial with 0.79^9 or 0.79^{10} $1 - 0.79^9 = 0.8801$ (< 0.9) or $0.79^9 = 0.1198$ (> 0.1) $1 - 0.79^{10} = 0.9053$ (> 0.9) or $0.79^{10} = 0.09468$ (< 0.1) Minimum n = 10 Accept n $\geq$ 10 --- NOTE: n = 10 unsupported scores SC1 only	----------------------------- M1(indep) for sight of 0.8801 **or** 0.1198 M1(indep) for sight of 0.9053 **or** 0.09468 A1 dep **on both M's** cao -----------------------------	3
		TOTAL	**16**

Q7 (i)	Positive	B1	**1**
(ii)	Number of people = 20×33 (000) + 5×58 (000) = 660 (000) + 290 (000) = 950 000	M1 first term M1(indep) second term A1 cao NB answer of 950 scores M2A0	**3**
(iii)	(*A*) *a* = 1810 + 340 = 2150 (*B*) Median = age of 1 385 (000th) person or 1385.5 (000) Age 30, cf = 1 240 (000); age 40, cf = 1 810 (000) Estimate median = (30) + $\frac{145}{570} \times 10$ Median = 32.5 years (32.54...) If no working shown then 32.54 or better is needed to gain the M1A1. If 32.5 seen with **no previous working** allow SC1	M1 for sum A1 cao 2150 or 2150 thousand but not 215000 B1 for 1 385 (000) or 1385.5 M1 for attempt to interpolate $\frac{145k}{570k} \times 10$ (2.54 or better suggests this) A1 cao min 1dp	**2** **3**
(iv)	Frequency densities: 56, 65, 77, 59, 45, 17 *(accept 45.33 and 17.43 for 45 and 17)* 	B1 for any one correct B1 for all correct (soi by listing or from histogram) **Note: all G marks below *dep* on attempt at frequency density, NOT frequency** G1 Linear scales on both axes (no inequalities) G1 Heights FT their listed fds or all must be correct. **Also widths. All blocks joined** G1 Appropriate label for vertical scale eg 'Frequency density (thousands)', 'frequency (thousands) per 10 years', 'thousands of people per 10 years'. (allow key). **OR f.d.**	**5**

(v)	Any two suitable comments such as: Outer London has a greater proportion (or %) of people under 20 (or almost equal proportion) The modal group in Inner London is 20-30 but in Outer London it is 30-40 Outer London has a greater proportion (14%) of aged 65+ **All** populations in **each** age group are higher in Outer London Outer London has a more evenly spread distribution or balanced distribution (ages) o.e.	E1 E1	**2**
(vi)	Mean increase ↑ median unchanged (-) midrange increase ↑ standard deviation increase ↑ interquartile range unchanged. (-)	Any one correct B1 Any two correct B2 Any three correct B3 All **five** correct B4	**4**
		TOTAL	**20**

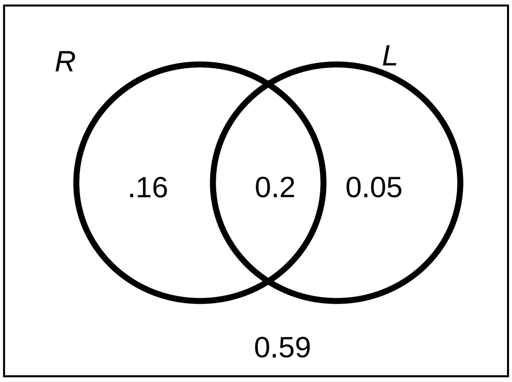
4766 Statistics 1

Section A

Q1 (i)	(With $\sum fx$ = 7500 and $\sum f$ = 10000 then arriving at the mean) (i) £0.75 scores (B1, B1) (ii) 75p scores (B1, B1) (iii) 0.75p scores (B1, B0) (incorrect units) (iv) £75 scores (B1, B0) (incorrect units) **After B0, B0** then sight of $\mathbf{\frac{7500}{10000}}$ scores SC1. SC1or an answer in the range £0.74 - £0.76 or 74p – 76p (both inclusive) scores SC1 (units essential to gain this mark)	B1 for numerical mean (0.75 or 75 seen) B1dep for correct units attached	
	Standard Deviation: (CARE NEEDED here with close proximity of answers) • 50.2(0) using divisor 9999 scores B2 (50.20148921) • 50.198 (= 50.2) using divisor 10000 scores B1(*rmsd*) • If divisor is not shown (or calc used) and only an answer of 50.2 (i.e. not coming from 50.198) is seen then award B2 on b.o.d. (default)	B2 correct s.d. (B1) correct rmsd (B2) default	
	After B0 scored then an attempt at S_{xx} as evident by either $S_{xx} = (5000 + 200000 + 25000000) - \frac{7500^2}{10000}$ (= 25199375) or $S_{xx} = (5000 + 200000 + 25000000) - 10000(0.75)^2$ **scores (M1) or M1ft 'their 7500^2' or 'their 0.75^2'** NB The structure must be correct in both above cases with a max of 1 slip only after applying the f.t.	$\sum fx^2$ **= 25,205,000** **Beware** $\sum x^2$ **=25, 010, 100** **After B0** scored then (M1) or M1f.t. for attempt at S_{xx} *NB full marks for correct results from recommended method which is use of calculator functions*	**4**

(ii)	P(Two £10 or two £100) $= \frac{50}{10000}\times\frac{49}{9999}+\frac{20}{10000}\times\frac{19}{9999}$ = 0.0000245 + 0.0000038 = (0.00002450245 + 0.00000380038) = 0.000028(3) o.e. = (0.00002830283) After M0, M0 then $\frac{\mathbf{50}}{\mathbf{10000}}\times\frac{\mathbf{50}}{\mathbf{10000}}+\frac{\mathbf{20}}{\mathbf{10000}}\times\frac{\mathbf{20}}{\mathbf{10000}}$ o.e. Scores SC1 (ignore final answer but SC1 may be implied by sight of 2.9×10^{-5} o.e.) Similarly, $\frac{\mathbf{50}}{\mathbf{10000}}\times\frac{\mathbf{49}}{\mathbf{10000}}+\frac{\mathbf{20}}{\mathbf{10000}}\times\frac{\mathbf{19}}{\mathbf{10000}}$ scores SC1	M1 for either correct product seen (ignore any multipliers) M1 sum of both correct (ignore any multipliers) A1 CAO (as opposite with no rounding) (SC1 case #1) (SC1 case #2) **CARE** answer is also 2.83×10^{-5}	**3**
		TOTAL	**7**
Q2 (i)	Either P(all correct) $=\frac{1}{6}\times\frac{1}{5}\times\frac{1}{4}\times\frac{1}{3}\times\frac{1}{2}\times\frac{1}{1}=\frac{1}{720}$ or P(all correct) $=\frac{1}{6!}=\frac{1}{720}=0.00139$	M1 for 6! Or 720 (sioc) or product of fractions A1 CAO (accept 0.0014)	**2**
(ii)	Either P(picks T, O, M) $=\frac{3}{6}\times\frac{2}{5}\times\frac{1}{4}=\frac{1}{20}$ or P(picks T, O, M) $=\frac{1}{6}\times\frac{1}{5}\times\frac{1}{4}\times3!=\frac{1}{20}$ or P(picks T, O, M) $=\frac{1}{\binom{6}{3}}=\frac{1}{20}$	M1 for denominators M1 for numerators or 3! A1 CAO Or M1 for $\binom{6}{3}$ or 20 sioc M1 for $1/\binom{6}{3}$ A1 CAO	**3**
		TOTAL	**5**
Q3 (i)	$p = 0.55$	B1 cao	**1**
(ii)	E(X) = $0\times0.55+1\times0.1+2\times0.05+3\times0.05+4\times0.25=1.35$ E(X^2) = $0\times0.55+1\times0.1+4\times0.05+9\times0.05+16\times0.25$ = 0 + 0.1 + 0.2 + 0.45 + 4 = (4.75) Var(X) = 'their' 4.75 – 1.35^2 = 2.9275 awfw (2.9275 – 2.93)	M1 for Σrp (at least 3 non zero terms correct) A1 CAO(no 'n' or 'n-1' divisors) M1 for Σr^2p (at least 3 non zero terms correct) M1dep for – their E(X)² provided Var(X) > 0 A1 cao (no 'n' or 'n-1' divisors)	**5**
(iii)	P(At least 2 both times) = $(0.05+0.05+0.25)^2$ = 0.1225 o.e.	M1 for $(0.05+0.05+0.25)^2$ or 0.35^2 seen A1cao: awfw (0.1225 - 0.123) or 49/400	**2**

		TOTAL	**8**

Q4 (i)	$X \sim B(50, 0.03)$ **(A)** $P(X=1) = \binom{50}{1} \times 0.03 \times 0.97^{49} = 0.3372$ **(B)** $P(X=0) = 0.97^{50} = 0.2181$ $P(X>1) = 1 - 0.2181 - 0.3372 = 0.4447$	M1 0.03×0.97^{49} or 0.0067(4)…. M1 $\binom{50}{1} \times pq^{49}$ (p+q =1) A1 CAO **(awfw 0. 337 to 0. 3372) or 0.34(2s.f.) or 0.34(2d.p.) but not just 0.34** B1 for 0.97^{50} or 0.2181 (awfw 0.218 to 0.2181) M1 for 1 – ('their' p (X = 0) + 'their' p(X = 1)) must have both probabilities A1 CAO (awfw 0.4447 to 0.445)	**3** **3**
(ii)	Expected number = np = 240 × 0.3372 = 80.88 – 80.93 = (81) *Condone 240 × 0.34 = 81.6 = (82) but for M1 A1f.t.*	M1 for 240 × prob (A) A1FT	**2**
		TOTAL	**8**
Q5 (i)	P(R) × P(*L*) = 0.36 × 0.25 = 0.09 ≠ P(*R*∩*L*) Not equal so not independent. (Allow 0.36 × 0.25 ≠ 0.2or 0.09 ≠ 0.2 or ≠ p(R ∩ L) so not independent)	M1 for 0.36 × 0.25 or 0.09 seen A1 (numerical justification needed)	**2**
(ii)		G1 for two overlapping circles labelled G1 for 0.2 and either 0.16 *or* 0.05 in the **correct places** G1 for all 4 **correct** probs in the **correct** places (including the 0.59) The last two G marks are independent of the labels	**3**
(iii)	$P(L \mid R) = \frac{P(L \cap R)}{P(R)} = \frac{0.2}{0.36} = \frac{5}{9} = 0.556$ (awrt 0.56) This is the probability that Anna is late given that it is raining. (must be in context) Condone 'if ' or 'when' or 'on a rainy day' for 'given that' but **not** the words 'and' or 'because' or 'due to'	M1 for 0.2/0.36 o.e. A1 cao E1 (indep of M1A1) **Order/structure must be correct i.e. no reverse statement**	**3**
		TOTAL	**8**

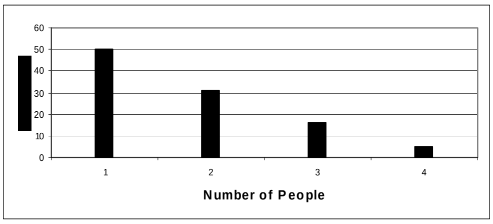
Section B

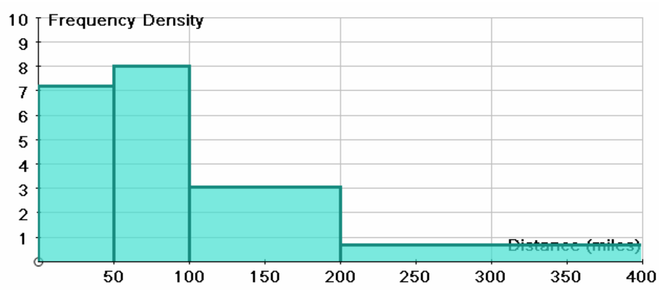
Q6 (i)	Median = 4.06 – 4.075 (inclusive) $Q_1 = 3.8$ $Q_3 = 4.3$ Inter-quartile range = 4.3 – 3.8 = 0.5	B1cao B1 for Q_1 (cao) B1 for Q_3 (cao) B1 ft for IQR must be using t-values not locations to earn this mark	**4**
(ii)	Lower limit ‘ their 3.8’ – 1.5 × ‘their 0.5’ = (3.05) Upper limit ‘ their 4.3’ + 1.5 × ‘their 0.5’ = (5.05) Very few if any temperatures <u>below 3.05 (but not zero)</u> None <u>above 5.05</u> ‘So few, if any outliers’ scores SC1	B1ft: must have -1.5 B1ft: must have +1.5 E1ft dep on -1.5 and Q_1 E1ft dep on+1.5 and Q_3 Again, must be using t-values NOT locations to earn these 4 marks	**4**
(iii)	Valid argument such as ‘Probably not, because there is nothing to suggest that they are not genuine data items; (they do not appear to form a separate pool of data.’) Accept: exclude outlier – ‘measuring equipment was wrong’ or ‘there was a power cut’ or ref to hot / cold day [Allow suitable valid alternative arguments]	E1	**1**
(iv)	Missing frequencies 25, 125, 50	B1, B1, B1 (all cao)	**3**
(v)	Mean = (3.2×25 + 3.6×125 + 4.0×243 + 4.4×157 + 4.8×50)/600 = 2432.8/600 = 4.05(47)	M1 for at least 4 midpoints correct and being used in attempt to find $\sum ft$ A1cao: awfw (4.05 – 4.055) ISW or rounding	**2**
(vi)	New mean = 1.8 × ‘their 4.05(47)’ + 32 = 39.29(84) to 39.3 New s = 1.8 × 0.379 = 0.682	B1 FT M1 for 1.8 × 0.379 A1 CAO awfw (0.68 – 0.6822)	**3**
		TOTAL	**17**

Q7 (i)	$X \sim B(10, 0.8)$ (***A***) *Either* $P(\boldsymbol{X} = 8) = \binom{10}{8} \times 0.8^8 \times 0.2^2 = 0.3020$ (awrt) *or* $P(X = 8) = P(X \le 8) - P(X \le 7)$ $= 0.6242 - 0.3222 = 0.3020$	M1 $0.8^8 \times 0.2^2$ or 0.00671… M1 $\binom{10}{8} \times p^8 q^2$; (p +q =1) Or $45 \times p^8 q^2$; (p +q =1) A1 CAO **(0.302) not 0.3** OR: M2 for 0.6242 – 0.3222 A1 CAO	**3**
	(***B***) *Either* $P(X \ge 8) = 1 - P(X \le 7)$ $= 1 - 0.3222 = 0.6778$ *or* $P(X \ge 8) = P(X = 8) + P(X = 9) + P(X = 10)$ $= 0.3020 + 0.2684 + 0.1074 = 0.6778$	M1 for 1 – 0.3222 (s.o.i.) A1 CAO awfw 0.677 – 0.678 or M1 for sum of 'their' p(X=8) plus correct expressions for p(x=9) and p(X=10) A1 CAO awfw 0.677 – 0.678	**2**
(ii)	Let $X \sim B(18, p)$ Let p = probability of delivery (within 24 hours) (for population) H_0: $p = 0.8$ H_1: $p < 0.8$ $P(X \le 12) = 0.1329 > 5\%$ ref: [pp =0.0816] So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that less than 80% of orders will be delivered within 24 hours Note: use of critical region method scores M1 for region {0,1,2,…,9, 10} M1dep for 12 does not lie in critical region then A1dep E1dep as per scheme	B1 for definition of p B1 for H_0 B1 for H_1 M1 for probability 0.1329 M1dep strictly for comparison of 0.1329 with 5% (seen or clearly implied) A1dep on both M's E1dep on M1,M1,A1 for conclusion in context	**7**

(iii)	Let $X \sim B(18, 0.8)$ H_1: $p \neq 0.8$ LOWER TAIL $P(X \leq 10) = 0.0163 < 2.5\%$ $P(X \leq 11) = 0.0513 > 2.5\%$ UPPER TAIL $P(X \geq 17) = 1 - P(X \leq 16) = 1 - 0.9009 = 0.0991 > 2.5\%$ $P(X \geq 18) = 1 - P(X \leq 17) = 1 - 0.9820 = 0.0180 < 2.5\%$ So critical region is {<u>0</u>,1,2,3,4,5,6,7,8,9,10,18} o.e. Condone $X \leq 10$ and $X \geq 18$ or X = 18 but **<u>not</u>** $p(X \leq 10)$ and $p(X \geq 18)$ Correct CR without supportive working scores SC2 max after the 1st B1 (SC1 for each fully correct tail of CR)	B1 for H_1 B1 for 0.0163 or 0.0513 seen M1dep for either correct comparison with **2.5% (not 5%)** (seen or clearly implied) A1dep for correct lower tail CR (must have zero) B1 for 0.0991 or 0.0180 seen M1dep for either correct comparison with **2.5% (not 5%)** (seen or clearly implied) A1dep for correct upper tail CR	**7**
		TOTAL	**19**

4766 Statistics 1

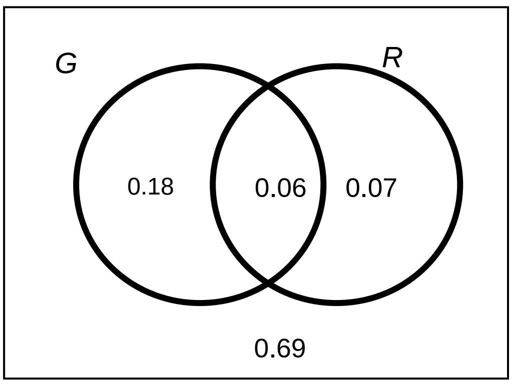
Q1 (i)	Median = 2 Mode = 1	B1 CAO B1 CAO	**2**
(ii)		S1 labelled linear scales on both axes H1 heights	**2**
(iii)	Positive	B1	**1**
		TOTAL	**5**
Q2 (i)	$\binom{25}{5}$ different teams = 53130	M1 for $\binom{25}{5}$ A1 CAO	**2**
(ii)	$\binom{14}{3}\times\binom{11}{2}=364\times 55=20020$	M1 for either combination M1 for product of both A1 CAO	**3**
		TOTAL	**5**
Q3 (i)	Mean = $\frac{126}{12}$ = 10.5 Sxx = $1582-\frac{126^2}{12}$ = 259 s = $\sqrt{\frac{259}{11}}$ = 4.85	B1 for mean M1 for attempt at *Sxx* A1 CAO	**3**
(ii)	New mean = 500 + 100 $\times$10.5 = 1550 New s = 100 $\times$4.85 = 485	B1 <u>ANSWER GIVEN</u> M1A1FT	**3**
(iii)	On average Marlene sells more cars than Dwayne. Marlene has less variation in monthly sales than Dwayne.	E1 E1FT	**2**
		TOTAL	**8**

Q4 (i)	E(X) = 25 because the distribution is symmetrical. Allow correct calculation of Σrp	E1 <u>ANSWER GIVEN</u>	**1**
(ii)	E(X²) = $10^2 \times 0.2 + 20^2 \times 0.3 + 30^2 \times 0.3 + 40^2 \times 0.2$ = 730 Var(X) = 730 – 25² = 105	M1 for $\Sigma r^2 p$ (at least 3 terms correct) M1dep for – 25² A1 CAO	**3**
		TOTAL	**4**
Q5 (i)	Distance / freq / width / f dens 0- / 360 / 50 / 7.200 50- / 400 / 50 / 8.000 100- / 307 / 100 / 3.070 200-400 / 133 / 200 / 0.665 	M1 for fds A1 CAO Accept any suitable unit for fd such as eg freq per 50 miles. L1 linear scales on both axes and label W1 width of bars H1 height of bars	**5**
(ii)	Median = 600th distance Estimate = 50 + $^{240}/_{400} \times 50$ = 50 + 30 = 80	B1 for 600th M1 for attempt to interpolate A1 CAO	**3**
		TOTAL	**8**
Q6 (i)	(*A*) P(at most one) $= \frac{83}{100} = 0.83$ (*B*) P(exactly two) $= \frac{10+2+1}{100} = \frac{13}{100} = 0.13$	B1 aef M1 for (10+2+1)/100 A1 aef	**1** **2**
(ii)	P(all at least one) $= \frac{53}{100} \times \frac{52}{99} \times \frac{51}{98} = \frac{140556}{970200} = 0.145$	M1 for $\frac{53}{100} \times$ M1*dep* for product of next 2 correct fractions A1 CAO	**3**
		TOTAL	**6**

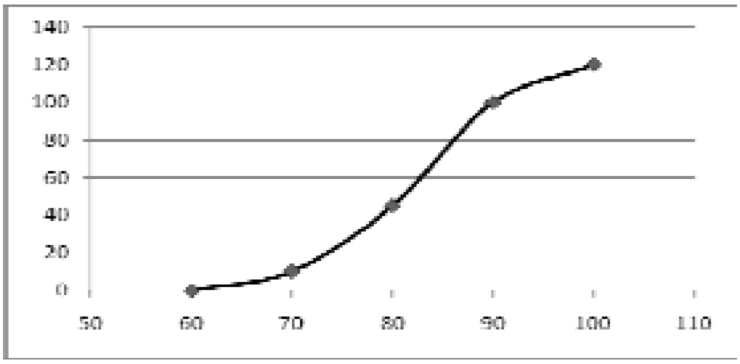
Q7 (i)	$a = 0.8$, $b = 0.85$, $c = 0.9$.	B1 for any one B1 for the other two	**2**
(ii)	P(Not delayed) = $0.8 \times 0.85 \times 0.9 = 0.612$ P(Delayed) = $1 – 0.8 \times 0.85 \times 0.9 = 1 – 0.612 = 0.388$	M1 for product A1 CAO M1 for 1 – P(delayed) A1FT	**4**
(iii)	P(just one problem) $= 0.2\times0.85\times0.9 + 0.8\times0.15\times0.9 + 0.8\times0.85\times0.1$ $= 0.153 + 0.108 + 0.068 = 0.329$	B1 one product correct M1 three products M1 sum of 3 products A1 CAO	**4**
(iv)	P(Just one problem | delay) $= \dfrac{\text{P(Just one problem and delay)}}{\text{P(Delay)}} = \dfrac{0.329}{0.388} = 0.848$	M1 for numerator M1 for denominator A1FT	**3**
(v)	P(Delayed | No technical problems) *Either* $= 0.15 + 0.85 \times 0.1 = 0.235$ *Or* $= 1 – 0.9 \times 0.85 = 1 – 0.765 = 0.235$ *Or* $= 0.15 \times 0.1 + 0.15 \times 0.9 + 0.85 \times 0.1 = 0.235$ *Or (using conditional probability formula)* $\dfrac{\text{P(Delayed and no technical problems)}}{\text{P(No technical problems)}}$ $= \dfrac{0.8\times0.15\times0.1+0.8\times0.15\times0.9+0.8\times0.85\times0.1}{0.8}$ $= \dfrac{0.188}{0.8} = 0.235$	M1 for 0.15 + M1 for second term A1CAO M1 for product M1 for 1 – product A1CAO M1 for all 3 products M1 for sum of all 3 products A1CAO M1 for numerator M1 for denominator A1CAO	**3**
(vi)	Expected number = $110 \times 0.388 = 42.7$	M1 for product A1FT	**2**
		TOTAL	**18**

Q8 (i)	X ~ B(15, 0.2) (*A*) $P(X = 3) = \binom{15}{3} \times 0.2^3 \times 0.8^{12} = 0.2501$ OR from tables $0.6482 - 0.3980 = 0.2502$ (*B*) $P(X \geq 3) = 1 - 0.3980 = 0.6020$ (*C*) $E(X) = np = 15 \times 0.2 = 3.0$	M1 $0.2^3 \times 0.8^{12}$ M1 $\binom{15}{3} \times p^3 q^{12}$ A1 CAO OR: M2 for 0.6482 – 0.3980 A1 CAO M1 P(X≤2) M1 1-P(X≤2) A1 CAO M1 for product A1 CAO	**3** **3** **2**
(ii)	(*A*) Let *p* = probability of a randomly selected child eating at least 5 a day H_0: $p = 0.2$ H_1: $p > 0.2$ (*B*) H_1 has this form as the proportion who eat at least 5 a day is expected to <u>increase</u>.	B1 for definition of *p* in context B1 for H_0 B1 for H_1 E1	**4**
(iii)	Let $X \sim B(15, 0.2)$ $P(X \geq 5) = 1 - P(X \leq 4) = 1 - 0.8358 = 0.1642 > 10\%$ $P(X \geq 6) = 1 - P(X \leq 5) = 1 - 0.9389 = 0.0611 < 10\%$ So critical region is {6,7,8,9,10,11,12,13,14,15} 7 lies in the critical region, so we reject null hypothesis and we conclude that there is evidence to suggest that the proportion who eat at least five a day has increased.	B1 for 0.1642 B1 for 0.0611 M1 for at least one comparison with 10% A1 CAO for critical region *dep* on M1 and at least one B1 M1 *dep* for comparison A1 *dep* for decision and conclusion **in context**	**6**
		TOTAL	**18**

4766 Statistics 1

1	(i)	5 | 2 6 | 3 4 7 8 7 | 1 2 2 3 4 5 5 7 9 8 | 1 Key 6 | 3 represents 63 mph	G1 stem G1 leaves CAO G1 sorted G1 key	**[4]**
	(ii)	Median = 72 Midrange = 66.5	B1 FT B1 CAO	**[2]**
	(iii)	*EITHER:* Median since midrange is affected by outlier (52) *OR:* Median since the lack of symmetry renders the midrange less representative	E1 for median E1 for explanation **TOTAL**	**[2]** **[8]**
2	(i)	(A) P(X = 10) = P(5 then 5) = 0.4×0.25 = 0.1 (B) P(X = 30) = P(10 and 20) = 0.4×0.25 + 0.2×0.5 = 0.2	B1 **ANSWER GIVEN** M1 for full calculation A1 **ANSWER GIVEN**	**[1]** **[2]**
	(ii)	$E(X) = 10\times0.1+15\times0.4+20\times0.1+25\times0.2+30\times0.2=20$ $E(X^2) =$ $100\times0.1+225\times0.4+400\times0.1+625\times0.2+900\times0.2=445$ $Var(X) = 445 - 20^2 = 45$	M1 for Σrp (at least 3 terms correct) A1 CAO M1 for Σr^2p (at least 3 terms correct) M1 dep for – their E (X)² A1 FT their E(X) provided Var(X) > 0 **TOTAL**	**[5]** **[8]**
3	(i)		G1 for two labelled intersecting circles G1 for at least 2 correct probabilities G1 for remaining probabilities	**[3]**
	(ii)	P(G) × P(R) = 0.24 × 0.13 = 0.0312 ≠ P(G∩R) or ≠ 0.06 So not independent.	M1 for 0.24 × 0.13 A1	**[2]**

	(iii)	$P(R\mid G)=\dfrac{P(R\cap G)}{P(G)}=\dfrac{0.06}{0.24}=\dfrac{1}{4}=0.25$	M1 for numerator M1 for denominator A1 CAO	**[3]**
			TOTAL	**[8]**
4	**(i)**	P(20 correct) = $\binom{30}{20}\times 0.6^{20}\times 0.4^{10}=0.1152$	M1 $0.6^{20}\times 0.4^{10}$ M1 $\binom{30}{20}\times p^{20}q^{10}$ A1 CAO	**[3]**
	(ii)	Expected number = 100 × 0.1152 = 11.52	M1 A1 FT (Must not round to whole number)	**[2]**
			TOTAL	**[5]**
5	**(i)**	P(Guess correctly) = 0.1^4 = 0.0001	B1 CAO	**[1]**
	(ii)	P(Guess correctly) = $\dfrac{1}{4!}=\dfrac{1}{24}$	M1 A1 CAO	**[2]**
			TOTAL	**[3]**
6	**(i)**	20 × 19 × 18 = 6840	M1 A1	**[2]**
	(ii)	20^3 – 20 = 7980	M1 for figures – 20 A1	**[2]**
			TOTAL	**[4]**

7	(i)	$10 \times 2 = 20$.	M1 for 10×2 A1 CAO	[2]
	(ii)	Mean = $\frac{10\times65+35\times75+55\times85+20\times95}{120}=\frac{9850}{120}=82.08$ It is an estimate because the data are grouped.	M1 for midpoints M1 for double pairs A1 CAO E1 indep	[4]
	(iii)	$10 \times 65^2 + 35 \times 75^2 + 55 \times 85^2 + 20 \times 95^2$ (= 817000) $S_{xx} = 817000-\frac{9850^2}{120}$ (= 8479.17) $s = \sqrt{\frac{8479.17}{119}} = 8.44$	M1 for Σfx^2 M1 for valid attempt at S_{xx} A1 CAO	[3]
	(iv)	$\bar{x} - 2s = 82.08 - 2\times8.44 = 65.2$ $\bar{x} + 2s = 82.08 + 2\times8.44 = 98.96$ So there are probably some outliers.	M1 FT for $\bar{x} - 2s$ M1 FT for $\bar{x} + 2s$ A1 for both E1 dep on A1	[4]
	(v)	Negative.	E1	[1]
	(vi)	Upper bound: 60, 70, 80, 90, 100 Cumulative frequency: 0, 10, 45, 100, 120 	C1 for cumulative frequencies S1 for scales L1 for labels 'Length and CF' P1 for points J1 for joining points dep on P1 All dep on attempt at cumulative frequency.	[5]
			TOTAL	[19]

8	**(i)**	(*A*) P(Low on all 3 days) = 0.5^3 = 0.125 or $^1/_8$	M1 for 0.5^3 A1 CAO	**[2]**
		(*B*) P(Low on at least 1 day) = 1 – 0.5^3 = 1 – 0.125 = 0.875	M1 for 1 – 0.5^3 A1 CAO	**[2]**
		(*C*) P(One low, one medium, one high) = 6 × 0.5 × 0.35 × 0.15 = 0.1575	M1 for product of probabilities 0.5 × 0.35 × 0.15 or $^{21}/_{800}$ M1 × 6 or × 3! or $^3P_3$ A1 CAO	**[3]**
	(ii)	X ~ B(10, 0.15) (*A*) P(No days) = 0.85^{10} = 0.1969 Or from tables P(No days) = 0.1969	M1 A1	**[2]**
		(*B*) *Either* P(1 day) $=\begin{pmatrix}10\\1\end{pmatrix}\times 0.15^1\times 0.85^9 = 0.3474$ *or* from tables P(1 day) = P($X \le 1$) – P($X \le 0$) = 0.5443 – 0.1969 = 0.3474	M1 $0.15^1 \times 0.85^9$ M1 $\binom{10}{1} \times p^1 q^9$ A1 CAO OR: M2 for 0.5443 – 0.1969 A1 CAO	**[3]**
	(iii)	Let *X* ~ B(20, 0.5) *Either:* P($X \ge 15$) = 1 – 0.9793 = 0.0207 < 5% *Or:* Critical region is {15,16,17,18,19,20} 15 lies in the critical region. So there is sufficient evidence to reject H_0 Conclude that there is enough evidence to indicate that the probability of low pollution levels is higher on the new street. H_1 has this form as she believes that the probability of a low pollution level is greater in this street.	*Either:* B1 for correct probability of 0.0207 M1 for comparison *Or:* B1 for CR, M1 for comparison A1 CAO dep on B1M1 E1 for conclusion in context E1 indep **TOTAL**	**[5]** **[17]**

GCE

Mathematics (MEI)

Advanced Subsidiary GCE **4766**

Statistics 1

Mark Scheme for June 2010

<table>
<tr><td>Q1
(i)</td><td>Positive skewness</td><td>B1</td><td>1</td></tr>
<tr><td>(ii)</td><td>Inter-quartile range = 10.3 – 8.0 = 2.3

Lower limit 8.0 – 1.5 × 2.3 = 4.55
Upper limit 10.3 + 1.5 × 2.3 = 13.75

Lowest value is 7 so no outliers at lower end
Highest value is 17.6 so at least one outlier at upper end.</td><td>B1

M1 for 8.0 – 1.5 × 2.3
M1 for 10.3 + 1.5 × 2.3

A1
A1</td><td>5</td></tr>
<tr><td>(iii)</td><td>Any suitable answers
Eg minimum wage means no very low values

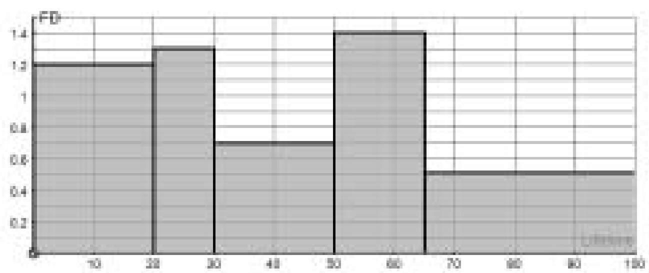
Highest wage earner may be a supervisor or manager or specialist worker or more highly trained worker</td><td>E1 one comment relating to low earners

E1 one comment relating to high earners</td><td>2</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>8</td></tr>
<tr><td>Q2
(i)</td><td>$4k + 6k + 6k + 4k = 1$
$20k = 1$
$k = 0.05$</td><td>M1

A1 NB Answer given</td><td>2</td></tr>
<tr><td>(ii)</td><td>$E(X) = 1\times0.2+2\times0.3+3\times0.3+4\times0.2 = 2.5$
(or by inspection)

$E(X^2) = 1\times0.2+4\times0.3+9\times0.3+16\times0.2 = 7.3$

$Var(X) = 7.3 - 2.5^2 = 1.05$</td><td>M1 for Σrp (at least 3 terms correct)
A1 CAO

M1 for Σr^2p (at least 3 terms correct)
M1dep for – their $E(X)^2$
A1 FT their E(X) provided Var(X) > 0</td><td>5</td></tr>
<tr><td></td><td></td><td>TOTAL</td><td>7</td></tr>
<tr><td>Q3
(i)</td><td>
<table>
<tr><th>Lifetime (x hours)</th><th>Frequency</th><th>Width</th><th>FD</th></tr>
<tr><td>$0 < x \le 20$</td><td>24</td><td>20</td><td>1.2</td></tr>
<tr><td>$20 < x \le 30$</td><td>13</td><td>10</td><td>1.3</td></tr>
<tr><td>$30 < x \le 50$</td><td>14</td><td>20</td><td>0.7</td></tr>
<tr><td>$50 < x \le 65$</td><td>21</td><td>15</td><td>1.4</td></tr>
<tr><td>$65 < x \le 100$</td><td>18</td><td>35</td><td>0.51</td></tr>
</table>


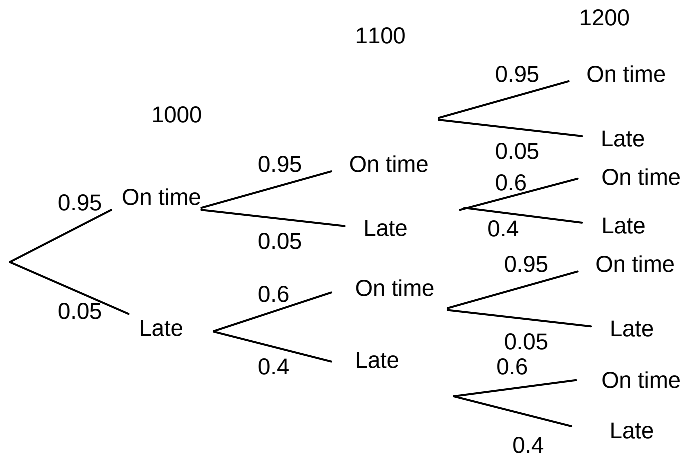
</td><td>M1 for fds
A1 CAO

Accept any suitable unit for fd such as eg freq per 10 hours.

L1 linear scales on both axes and label on vert axis

W1 width of bars
H1 height of bars</td><td>5</td></tr>
</table>

(ii)	Median lies in third class interval ($30 < x \leq 50$) Median = 45.5th lifetime (which lies beyond 37 but not as far as 51)	B1 CAO E1 *dep* on B1	**2**
		TOTAL	**7**
Q4 (i)	$1 \times \frac{1}{5} = \frac{1}{5}$	M1 A1	**2**
(ii)	$1\times\frac{4}{5}\times\frac{3}{5}\times\frac{2}{5}\times\frac{1}{5}=\frac{24}{625}=0.0384$	M1 For $1\times\frac{4}{5}\times$ *or just* $\frac{4}{5}\times$ M1 *dep* for fully correct product A1	**3**
(iii)	1 – 0.0384 = 0.9616 or 601/625	B1	**1**
		TOTAL	**6**
Q5 (i)	Mean = $\frac{0\times37+1\times23+2\times11+3\times3+4\times0+5\times1}{75}=\frac{59}{75}=0.787$ S_{xx} = $0^2\times37+1^2\times23+2^2\times11+3^2\times3+4^2\times0+5^2\times1-\frac{59^2}{75}=72.59$ s = $\sqrt{\frac{72.59}{74}}$ = 0.99	M1 A1 M1 for Σfx^2 s.o.i. M1 *dep* for good attempt at S_{xx} BUT NOTE M1M0 if their $S_{xx} < 0$ A1 CAO	**5**
(ii)	New mean = 0.787 × £1.04 = £0.818 or 81.8 pence New s = 0.99 × £1.04 = £1.03 or 103 pence	B1 ft their mean B1 ft their s B1 for correct units *dep* on at least 1 correct (ft)	**3**
		TOTAL	**8**
	Section B		
Q6 (i)	X ~ B(18, 0.1) (***A***) P(2 faulty tiles) $=\binom{18}{2}\times0.1^2\times0.9^{16}=0.2835$ OR from tables $0.7338-0.4503=0.2835$	M1 $0.1^2 \times 0.9^{16}$ M1 $\binom{18}{2}\times p^2q^{16}$ A1 CAO OR: M2 for 0.7338 – 0.4503 A1 CAO	**3**
	(***B***) P(More than 2 faulty tiles) $=1-0.7338=0.2662$	M1 P($X\leq2$) M1 *dep* for 1-P(X≤2) A1 CAO	**3**

	(*C*) $E(X) = np = 18 \times 0.1 = 1.8$	M1 for product 18×0.1 A1 CAO	2
(ii)	(*A*) Let p = probability that a randomly selected tile is faulty H_0: $p = 0.1$ H_1: $p > 0.1$	B1 for definition of p in context B1 for H_0 B1 for H_1	3
	(*B*) H_1 has this form as the manufacturer believes that the number of faulty tiles may <u>increase</u>.	E1	1
(iii)	Let $X \sim B(18, 0.1)$ $P(X \geq 4) = 1 - P(X \leq 3) = 1 - 0.9018 = 0.0982 > 5\%$ $P(X \geq 5) = 1 - P(X \leq 4) = 1 - 0.9718 = 0.0282 < 5\%$ So critical region is {5,6,7,8,9,10,11,12,13,14,15,16,17,18}	B1 for 0.0982 B1 for 0.0282 M1 for at least one comparison with 5% A1 CAO for critical region *dep* on M1 and at least one B1	4
(iv)	4 does not lie in the critical region, (so there is insufficient evidence to reject the null hypothesis and we conclude that there is not enough evidence to suggest that the number of faulty tiles has increased.	M1 for comparison A1 for conclusion **in context**	2
		TOTAL	**18**
Q7 **(i)**		G1 first set of branches G1 *indep* second set of branches G1 *indep* third set of branches G1 labels	4

(ii)	(*A*) P(all on time) = $0.95^3 = 0.8574$	M1 for 0.95^3 A1 CAO	**2**
	(*B*) P(just one on time) = $0.95\times0.05\times0.4 + 0.05\times0.6\times0.05 + 0.05\times0.4\times0.6$ $= 0.019 + 0.0015 + 0.012 = 0.0325$	M1 first term M1 second term M1 third term A1 CAO	**4**
	(*C*) P(1200 is on time) = $0.95\times0.95\times0.95 + 0.95\times0.05\times0.6 + 0.05\times0.6\times0.95 + 0.05\times0.4\times0.6 = 0.857375+0.0285+0.0285+0.012= 0.926375$	M1 any two terms M1 third term M1 fourth term A1 CAO	**4**
(iii)	P(1000 on time given 1200 on time) = P(1000 on time and 1200 on time) / P(1200 on time) = $\frac{0.95\times0.95\times0.95+0.95\times0.05\times0.6}{0.926375} = \frac{0.885875}{0.926375} = 0.9563$	M1 either term of numerator M1 full numerator M1 denominator A1 CAO	**4**
		Total	**18**

RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4766:** Statistics 1

Mark Scheme for January 2011

Oxford Cambridge and RSA Examinations

	SECTION A			
Q1 (i)	Mode = 960 (grams) Median = 1020 (grams) N.B. 96 and 102 gets SC1	B1 CAO B1 CAO	**2**	Ignore units and working
(ii)	Positive	E1	**1**	Not right skewed Not positive correlation
		TOTAL	**3**	
Q2 (i)	P(product of two scores < 10) = $\frac{13}{16}$ = 0.8125	B1	**1**	Allow 0.813 or 0.812
(ii)	P(*even*) × P(< 10) = 0.5 × $\frac{13}{16}$ = $\frac{13}{32}$ = 0.40625 P(*even* ∩ < 10) = $\frac{6}{16}$ = 0.375 So not independent.	M1 for 0.5 × $\frac{13}{16}$ or $\frac{13}{32}$ FT their answer to (i) M1 for $\frac{6}{16}$ A1	**3**	Do not allow these embedded in probability formulae Also allow P(even|<10) = 6/13≠ P(even) = 1/2 Or P(<10|even) = 6/8≠ P(<10) = 13/16 Or P(even|<10) = 6/13≠ P(even|<10') = 2/3 Or P(<10|even) = 6/8≠ P(<10|even') = 7/8 For all of these alternatives allow M2 for both probabilities. (M1 not available except if they correctly state both probabilities EG P(even|<10) and P(even) and get one correct) If they do not state what probabilities they are finding, give M2 for one of the above pairs of probabilities with ≠ symbol
		TOTAL	**4**	

Q3 (i)	$\binom{13}{3}$ ways of choosing the men = 286	M1 for $\binom{13}{3}$ seen A1	**2**	Accept $^{13}C_3$ or $^{13!}/_{(3!10!)}$ or equivalent for M1 No marks for permutations
(ii)	$\binom{13}{3} \times \binom{10}{3} = 286 \times 120 = 34320$	M1 for product A1 FT their 286	**2**	For permutations 1716 × 720 = 1235520 allow SC1 406 (from 286 + 120) scores SC1 (without further working)
(iii)	$\binom{23}{6} = 100947$ 34320/100947 = 1040/3059 = 0.340 (allow 0.34)	M1 for denominator of $\binom{23}{6}$ A1 FT	**2**	FT their 34320 Or $^6C_3 \times 13/23 \times 12/22 \times 11/21 \times 10/20 \times 9/19 \times 8/18$ = 0.340 scores M1 for product of fractions and A1 for $^6C_3\times$ and correct evaluation For permutations 1235520/72681840=0.017 scores SC1 Allow full marks for fractional answers, even if unsimplified 406/100947 = 0.00402 gets M1A1 with or without working
		TOTAL	**6**	

Q4 (i)	$2k + 6k + 12k + 20k + 30k = 1,\ 70k = 1$ $k = \dfrac{1}{70}$	M1 A1 NB **ANSWER GIVEN**	**2**	For five multiples of k (at least four correct multiples) Do not need to sum or =1 for M1 Condone omission of either $70k = 1$ or $k = 1/70$ but not both Condone omission of k: 2+6+12+20+30=70 Allow substitution of $k = 1/70$ into formula and getting at least four of 2/70, 6/70, 12/70, 20/70, 30/70 for M1 and 2/70+6/70+12/70+20/70+30/70 = 1 for A1
(ii)	$\mathrm{E}(X) = 1\times\dfrac{2}{70}+2\times\dfrac{6}{70}+3\times\dfrac{12}{70}+4\times\dfrac{20}{70}+5\times\dfrac{30}{70}=4$ $\mathrm{E}(X^2) =$ $1\times\dfrac{2}{70}+4\times\dfrac{6}{70}+9\times\dfrac{12}{70}+16\times\dfrac{20}{70}+25\times\dfrac{30}{70}=\dfrac{1204}{70}=17.2$ $\mathrm{Var}(X) = 17.2 - 4^2 = 1.2$	M1 for Σrp (at least 3 terms correct) A1 CAO M1 for Σr^2p (at least 3 terms correct) M1dep for - their $\mathrm{E}(X)^2$ A1 FT their E(X) but not an error in $\mathrm{E}(X^2)$ provided $\mathrm{Var}(X) > 0$	**5**	280/70 scores M1A0 USE of $\mathrm{E}(X-\mu)^2$ gets M1 for attempt at $(x-\mu)^2$ should see $(-3)^2$, $(-2)^2$, $(-1)^2$, 0^2, 1^2 (if $\mathrm{E}(X)$ correct but FT their $\mathrm{E}(X)$) (all 5 correct for M1), then M1 for $\Sigma p(x-\mu)^2$ (at least 3 terms correct with their probabilities) Allow all M marks with their probabilities, (unless not between 0 and 1, see below for all probs 1/70). Division by 5 or other spurious value at end gives max M1A1M1M1A0, or M1A0M1M1A0 if $\mathrm{E}(X)$ also divided by 5. Unsupported correct answers get 5 marks. SC2 for use of 1/70 for all probabilities leading to E(X) = 3/14 and Var(X) = 145/196 = 0.74
		TOTAL	**7**	

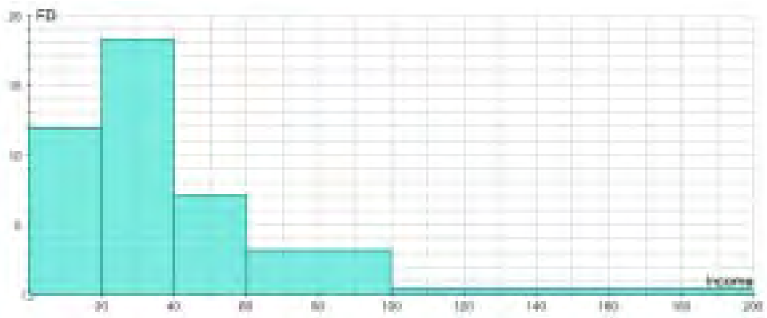
Q5 (i)	P(Wet and bus) = 0.4×0.7 = 0.28	M1 for multiplying probabilities A1 CAO	**2**	Fractional answer = 7/25 (Allow 28/100)
(ii)	P(Walk or bike) = $0.6 \times 0.5 + 0.6 \times 0.4 + 0.4 \times 0.2 + 0.4 \times 0.1$ or 0.3+0.24+0.08+0.04 = 0.66	M1 for any two correct pairs M1 for sum of all four correct terms With no extra terms for second M1 A1 CAO	**3**	Or = $0.6 \times 0.9 + 0.4 \times 0.3$ gets M1 for either term = 0.54 + 0.12 gets M1 for sum of both A1 CAO Or = 1 – 0.6×0.1 – 0.4×0.7 = 0.66. M1 for 1 – one correct term, M1 for complete correct expression and A1 for correct evaluation.
(iii)	P(Dry given walk or bike) $= \frac{\text{P(Dry and walk or bike)}}{\text{P(Walk or bike)}}$ $= \frac{0.6 \times 0.9}{0.66} = \frac{0.54}{0.66} = \frac{9}{11} = 0.818$	M1 for numerator leading to 0.54 M1 for denominator Ft their P(Walk or bike) from (ii) provided between 0 and 1 A1 FT	**3**	Allow 0.82, not 0.819 More accurate answer =0.81818 Fractional answer = 54/66 = 27/33 = 9/11 Condone answer of 0.8181 Do not give final A1 if ans ≥ 1
		TOTAL	**8**	

Q6 (i)	(*A*) P(Avoided air travel) $= \dfrac{7}{100} = 0.07$	B1 aef isw	**1**	
	(*B*) P(At least two) $= \dfrac{11+2+1+4}{100} = \dfrac{18}{100} = \dfrac{9}{50} = 0.18$	M1 for (11+2+1+4)/100 A1 aef isw	**2**	For M1 terms must be added must be as above or better with no extra terms (added or subtracted) for M1 Must simplify to 18/100 or 9/50 or 0.18 for A1 SC1 for 18/58 Or 1 – (14+26+0+42)/100 = 0.18 gets M1A1
(ii)	P(Reduced car use | Avoided air travel) $= \dfrac{6}{7} = 0.857$	M1 for denominator 7 or 7/100 or 0.07 FT their (i)A A1 CAO	**2**	Allow 0.86
(iii)	P(None have avoided air travel) $= \dfrac{93}{100} \times \dfrac{92}{99} \times \dfrac{91}{98} = 0.8025$	M1 for 93/100× (triple product) M1 for product of remaining fractions A1	**3**	Fuller answer 0.802511, so allow 0.803 without working, but 0.80 or 0.8 only with working . $(93/100)^3$ scores M1M0A0 which gives answer 0.804357 so watch for this. M0M0A0 for binomial probability including 0.93^{100} but ${}^3C_0 \times 0.07^0 \times 0.93^3$ still scores M1 $(k/100)^3$ for values of k other than 93 scores M0M0A0 $\frac{k}{100} \times \frac{(k-1)}{99} \times \frac{(k-2)}{98}$ for values of k other than 93 scores M1M0A0 Correct working but then multiplied or divided by some factor scores M1M0A0 ${}^{93}P_3 \ / \ {}^{100}P_3 = 0.803$ ${}^{93}P_3$ seen M1 divided by ${}^{100}P_3$ M1 0.803 A1 ${}^{93}C_3 \ / \ {}^{100}C_3 = 0.803$ Allow unsimplified fractional answer 778596/970200 =9269/11550
		TOTAL	**8**	

SECTION B

Q7 (i)

Income	Frequency	Width	FD
$0 \le x \le 20$	238	20	11.9
$20 < x \le 40$	365	20	18.25
$40 < x \le 60$	142	20	7.1
$60 < x \le 100$	128	40	3.2
$100 < x \le 200$	45	100	0. 5



<u>INCORRECT DIAGRAMS:</u>
Frequency diagrams can get M0, A0, L0, W1, H0 MAXIMUM
Thus frequency density = frequency × width, frequency/midpoint etc gets MAX M0A0L0W1H0

M1 for fds
A1 CAO

Accept any suitable unit for fd such as eg freq per £1000.

L1 linear scale and label on vertical axis

W1 linear scale on horizontal axis and correct width of bars

H1 height of bars

5

At least 4 fds correct for M1
M1 can be also be gained from freq per 10K - 119, 182.5, 71, 32, 4.5 (at least 4 correct) and A1 for all correct
Accept any suitable unit for fd, eg freq per £10K, BUT NOT FD per £1000
Allow fds correct to at least one 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 although given fd wrong

For L1, label required on vert axis in relation to first M1 mark ie fd or frequency density or if relevant freq/£10K, freq/£k etc (NOT fd/£10K)
Accept f/w or f/cw (freq/width or freq/class width)
Ignore horizontal label
L1 can also be gained from an accurate key – may see 1 square = 36.5 or 23.8 or 14.2

For W1, must be drawn at 0, 20, 40 etc NOT 19.5 or 20.5 etc NO GAPS ALLOWED
Must have linear scale.
No inequality labels on their own such as 0≤I<20, 20≤I<40 etc but allow if a clear horizontal linear scale is also given.

FT of heights *dep* on M1 all must agree with their fds
If fds not given and one height is wrong then max M1A0L1W1H0
– visual check only (within one square) –no need to measure precisely

(ii)	Mean = $\dfrac{10\times238+30\times365+50\times142+80\times128+150\times45}{918}$ $=\dfrac{37420}{918}=40.8$	M1 for midpoints M1 for midpoints ×frequencies with divisor 918 A1 CAO	**3**	At least three midpoints correct for M1 (seen in (ii) or in table in (i)) No marks if not using midpoints Second M1 for sight of at least 3 double pairs seen out of 10 × 238 + 30 × 365 + 50 × 142 + 80 × 128 + 150 × 45 with divisor 918 Numerator = 2380+10950+7100+10240+6750 Use of LCB or UCB for midpoints here scores 0 For answer 40.76 or 40.8 or 41 mark as B3 37420/918 o.e. scores M1M1A0 NB Accept answers seen without working in part (ii) or (iii) (from calculator) Use of 'not quite right' midpoints such as 10.5, 30.5, etc can get M0M1A0 here and SC3 in (iii) Watch for incorrect method 238/10+365/30+142/50+128/80+45/150=40.71 Allow max 4 sf in final answer Also accept £40760, £40800 etc
(iii)	$\sum fx^2 = 238\times10^2+365\times30^2+142\times50^2+128\times80^2+45\times150^2$ = 2539000 Or 238×100 + 365×900 + 142×2500 + 128×6400 + 45×22500 = 2539000 Or 2380×10 + 10950×300 + 7100×50 + 10240×80 + 13500×150 =2539000 $S_{xx} = 2539000-\dfrac{37420^2}{918}=1013666$ $s=\sqrt{\dfrac{1013666}{917}}=33.2$	M1 for at least 3 multiples fx^2 A1 for Σfx^2 M1 for attempt at S_{xx} Dep on first M1 BUT NOTE M1M0 if their $S_{xx}<0$ A1 CAO If using LCB or UCB	**4**	For A1, all midpoints and frequencies correct Or $Sxx = 2539000 - 918\times40.76^2 = 1013855$, s=33.25. Using mean 40.8 leads to 1010861 , s= 33.20, Using mean = 41 leads to Sxx = 995844 and s = 32.95 M1M1 for $\sum f(x\text{-}x\text{bar})^2$ M1 for first three terms, M1 for all 5 terms $238\times(10\text{-}40.76)^2+365\times(30\text{-}40.76)^2+142\times(50\text{-}40.76)^2+128\times(80\text{-}40.76)^2+45\times(150\text{-}40.76)^2$ (= 1013666) A1 for S_{xx} = 1013666 A1 for final answer

		consistently then allow SC2 if working is fully correct but SC0 otherwise but no marks in part (ii)		For answer 33.25 or 33.3 or 33.2 (www) can just mark as B4 - these may be from calculator without working Allow 33 with correct working rmsd = $\sqrt{(1013666/918)}$ (=33.23) gets M1A1M1A0 (if seen) **WATCH FOR DIVISOR OF 918** Allow max 4 sf in final answer Allow £33200 etc
(iv)	($\bar{x}$ – 2*s* = 40.76 – 2×33.25 = –25.74) $\bar{x}$ + 2*s* = 40.76 + 2×33.25 = 107.26 Comment that there are almost certainly some outliers. Appropriate comment such as 'No, since there is nothing to indicate that these high earners represent a separate population.'	M1 for $\bar{x}$ + 2*s* or $\bar{x}$ – 2*s* A1 for 107.26 (FT) E1 E1 Dep on upper limit in range 106 - 108	**4**	FT any positive mean and positive sd 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 × standard deviation', do NOT award M1 (This rule of not following through variables applies in all situations) Award E0E0 if their upper limit > 200 Allow 'Must be some outliers' Allow any comments that implies that there are outliers No marks in (iv) unless using $\bar{x}$ + 2*s* or $\bar{x}$ – 2*s*
(v)	New mean = 1.15 × 40.76 = 46.87 New variance = $1.15^2 \times 33.25^2$ = 1462 For misread 1.5 in place of 1.15 For 1.5 × 40.76 = 61.1 and $1.5^2 \times 33.25^2$ = 2490 allow SC2 if all present but SC0 otherwise	B1 FT M1A1 FT	**3**	FT their mean (if given to ≥ 2 s.f.) FT their s (if given to ≥ 2 s.f.) provided their s>0 If RMSD found in part (i) rather than s, then FT their RMSD For new SD = 38.24 found instead of variance give M1A0 even if called variance (and FT their *s*) M0A0 for 1.15 x 33.25^2= 1271 Allow max 4 sf in final answers Min 2 sf If candidate 'starts again' only award marks for CAO
		TOTAL	**19**	

Q8 **(i)**	E(X) = $np = 12 \times 0.2 = 2.4$ Do not allow subsequent rounding.	M1 for product A1 CAO	**2**	If wrong n used consistently throughout, allow M marks only. NB If they round to 2, even if they have obtained 2.4 first they get M1A0. For answer of '2.4 or 2 if rounded up' allow M1A0 Answer of 2 without working gets M0A0. If they attempt E(X) by summing products xp give no marks unless answer is fully correct.
(ii)	X ~ B(12, 0.2) (***A***) P(Wins exactly 2) $= \binom{12}{2} \times 0.2^2 \times 0.8^{10} = 0.2835$ OR from tables $0.5583 - 0.2749 = 0.2834$	M1 $0.2^2 \times 0.8^{10}$ M1 $\binom{12}{2} \times p^2 q^{10}$ A1 CAO OR: M2 for 0.5583 – 0.2749 A1 CAO	**3**	With $p + q = 1$ Also for 66 × 0.004295 Allow answers within the range 0.283 to 0.284 with or without working or 0.28 to 0.283 if working shown See tables at the website http://www.mei.org.uk/files/pdf/formula_book_mf2.pdf
	(***B***) P(Wins at least 2) $= 1 - 0.2749 = 0.7251$	M1 P($X \le 1$) M1 1-P($X \le 1$) A1 CAO	**3**	M1 0.2749 seen M1 1 – 0.2749 seen Allow 0.725 to 0.73 but not 0.72. Point probability method: P(1) = $12 \times 0.2 \times 0.8^{11}$ = 0.2062 , P(0) = 0.8^{12} = 0.0687 So P($X \le 1$) = 0.2749 gets M1 then mark as per scheme SC1 for 1 – P($X \le 2$) = 1 – 0.5583 = 0.4417 For misread of tables value of 0.2749 , allow 0 in (*A*) but MAX M1M1 in (*B*) For P(X>1) = P(X=2) + P(X=3) + P(X=4) +.... allow M1 for 0.2835+0.2362+0.1329+0.0532+0.0155 and second M1 for 0.0033+0.0005+0.0001 and A1 for 0.725 or better M0M0A0 for 1 - P(X=1) = 1 – 0.2062 = 0.7938

(iii)	Let p = probability that Ali wins a game H_0: $p = 0.2$ H_1: $p > 0.2$ H_1 has this form as Ali claims that he is better at winning games than Mark is.	B1 for definition of p in context B1 for H_0 B1 for H_1 E1	**4**	Minimum needed for B1 is p = probability that Ali wins. Allow p = P(Ali wins) 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 Ali wins a game, NOT just a sentence ‘probability is 0.2’ H_0 : p(Ali wins) = 0.2, H_1 : p(Ali wins) > 0.2 gets B0B1B1Allow p=20%, allow θ or π and ρ but not x. However allow any single symbol <u>if defined</u> Allow $H_0 = p$=0.2, Allow H_0 : $p={}^2/_{10}$ Do not allow H_0 : $P(X=x) = 0.2$, H_1 : $P(X=x) > 0.2$ Do not allow H_0: =0.2, =20%, P(0.2), p(0.2), p(x)=0.2, x=0.2 (unless x correctly defined as a probability) Do not allow H_1:$p \geq 0.2$, Do not allow H_0 and H_1 reversed for B marks but can still get E1 Allow NH and AH in place of H_0 and H_1 For hypotheses given in words allow Maximum B0B1B1E1 Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.2 oe.
	EITHER Probability method: $P(X \geq 7) = 1 - P(X \leq 6)$ $= 1 - 0.9133 = 0.0867 > 5\%$ 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 Ali is better at winning games than Mark. Must include ‘not enough evidence’ or something similar for E1. ‘Not enough evidence’ can be seen in the either for the A mark or the E mark. Do not allow final conclusions for E1 such as : 'there is evidence to suggest that Ali is no better at winning games than Mark' or 'Mark and Ali have equal probabilities of winning games'	B1 for $P(X \geq 7)$ B1 for 0.0867 Or 1 – 0.9133 seen M1 for comparison with 5% dep on B1 for 0.0867 A1 for not significant or ‘accept H_0’ or ‘cannot reject H_0’ or ‘reject H_1’ E1 dep on M1A1 Do not award first B1 for poor symbolic notation such as $P(X = 7) = 0.0867$ This comment applies to all methods	**5**	Zero for use of point prob - $P(X = 7) = 0.0546$

	OR Critical region method: Let $X \sim B(20, 0.2)$ $P(X \geq 7) = 1 - P(X \leq 6) = 1 - 0.9133 = 0.0867 > 5\%$ $P(X \geq 8) = 1 - P(X \leq 7) = 1 - 0.9679 = 0.0321 < 5\%$ So critical region is {8,9,10,11,12,13,14,15,16,17,18,19,20} 7 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 Ali is better at winning games than Mark.	B1 for 0.0867 B1 for 0.0321 M1 for at least one comparison with 5% A1 CAO for critical region and not significant or 'accept H_0' or 'cannot reject H_0' or 'reject H_1' *dep* on M1 and at least one B1 E1 dep on M1A1		Allow any form of statement of CR eg $X \geq 8$, 8 to 20, 8 or above, $X > 8$, {8, …}, annotated number line, etc but not $P(X \geq 8)$ {8,9,10,11,12} gets max B2M1A0 – tables stop at 8. NB USE OF POINT PROBABILITIES gets B0B0M0A0 Use of complementary probabilities Providing there is sight of 95%, allow B1 for 0.9133, B1 for 0.9679, M1 for comparison with 95% A1CAO for correct CR See additional notes below the scheme for other possibilities **PLEASE CHECK THAT THERE IS NO EXTRA WORKING ON THE SECOND PAGE IN THE ANSWER BOOKLET**
		TOTAL	**17**	

<u>NOTE RE OVER-SPECIFICATION OF ANSWERS</u>

If answers are grossly over-specified (see instruction 8), deduct the final answer mark in every case, except where there are more than two over-specified answers in a single question (only likely in question 7) in which case deduct a mark in only the first two cases of over-specification in that question. Probabilities should also be rounded to a sensible degree of accuracy.

<u>ADDITIONAL NOTES RE Q8 PART iii</u>

<u>Use of n = 12</u>

$P(X \geq 7) = 1 - P(X \leq 6) = 1 - 0.9961 = 0.0039 < 5\%$

So significant or reject H_0 etc, so there evidence to suggest that Ali is better at winning games than Mark.

Gets B1 for $P(X \geq 7)$ B1 for 0.0039 M1 for comparison with 5% dep on B1 for 0.0039 A1 for significant E1 for evidence to suggest that Ali is better at winning games than Mark. Then award MR -1 so maximum of 4 possible

<u>Comparison with 95% method</u>

B1 for $P(X \leq 6)$

B1 for 0.9133

M1 for comparison with 95% dep on B1
A1 for not significant or 'accept H_0' or 'cannot reject H_0'
E1

Smallest critical region method:

Either:
Smallest critical region that 7 could fall into gets B1 and has size 0.0867 gets B1, This is > 5% gets M1, A1, E1 as per scheme
NB These marks only awarded if 7 used, not other values.

Use of *k* method with no probabilities quoted:

$P(X \geq 7) = 1 - P(X \leq 6) > 5\%$
$P(X \geq 8) = 1 - P(X \leq 7) < 5\%$
These may be seen in terms of *k* or *n*.
Either $k = 8$ or $k - 1 = 7$ so $k = 8$ gets SC1
so CR is {8,9,10,11,12,13,14,15, 16, 17, 18, 19, 20} gets another SC1and conclusion gets another SC1

Use of *k* method with one probability quoted:

1 - 0.9679 < 5% or 0.0321 < 5% gets B0B1M1
$P(X \leq k - 1) = P(X \leq 7)$
so $k - 1 = 7$ so $k = 8$ (or just $k = 8$)
so CR is {8,9,10,11,12,13,14,15, 16, 17, 18, 19, 20} and conclusion gets A1E1

Two tailed test with H_1: $p \neq 0.2$
Hyp gets max B1B1B0E0
$P(X \geq 7) = 0.0867$ gets B1B1comparison with 2.5% gets M1 (must be 2.5%)
Final marks A0E0

Two tailed test done but with correct H_1: $p > 0.2$
Hyp gets max B1B1B1E1

if compare with 5% ignore work on lower tail and mark upper tail as per scheme so can score full marks
if compare with 2.5% no marks B0B0M0A0E0

One tailed test with H_1: $p<0.2$
Hyp gets max B1B1B0E0
no further marks B0B0M0A0E0

Lower tailed test with H_1: $p>0.2$
Hyp gets max B1B1B0E0
no further marks B0B0M0A0E0

Line diagram method
B1 for squiggly line between 7 and 8 or on 8 exclusively (ie just one line), B1*dep* for arrow pointing to right, M1 0.0321 seen on diagram from squiggly line or from 8, A1E1 for correct conclusion

Bar chart method
B1 for line clearly on boundary between 7 and 8 or within 8 block exclusively (ie just one line),, B1*dep* for arrow pointing to right, M1 0.0321 seen on diagram from boundary line or from 8, A1E1 for correct conclusion

Using P(Not faulty) method
H_0: $p=0.8$, H_1: $p<0.8$, where p represents the prob that Ali loses a game Ali claims that the proportion of games that he loses is less than 80% gets B1B1B1E1
$P(X\leq 13)=0.0867>5\%$ 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 Ali is better at winning games than Mark. Gets B1B1M1A1E1

RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

Advanced Subsidiary GCE

Unit **4766:** Statistics 1

Mark Scheme for June 2011

1. 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.

2. For answers scoring no marks, you must either award NR (no response) or 0, as follows:

   Award NR (no response) if:
   - Nothing is written at all in the answer space
   - There is a comment which does not in any way relate to the question being asked ("can't do", "don't know", etc.)
   - There is any sort of mark that is not an attempt at the question (a dash, a question mark, etc.)

   The hash key [#] on your keyboard will enter NR.

   Award 0 if:
   - There is an attempt that earns no credit. This could, for example, include the candidate copying all or some of the question, or any working that does not earn any marks, whether crossed out or not.

3. The following abbreviations may be used in this mark scheme.

M1	method mark (M2, etc, is also used)
A1	accuracy mark
B1	independent mark
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
ft	follow through
isw	ignore subsequent working
oe	or equivalent
rot	rounded or truncated
sc	special case
soi	seen or implied
www	without wrong working

4. Annotating scripts. The following annotations are available:

   ✓and ✗
   BOD Benefit of doubt
   FT Follow through
   ISW Ignore subsequent working (after correct answer obtained)
   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 Misread
   Highlighting is also available to highlight any particular points on a script.

5. The comments box will be used by the Principal Examiner to explain his or her marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts.

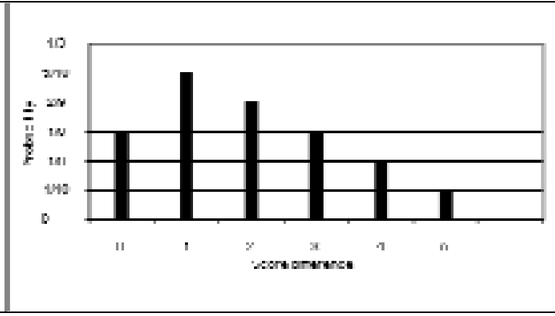
   Please do not type in the comments box yourself. Any questions or comments you have for your Team Leader should be communicated by the *scoris* messaging system, e-mail or by telephone.

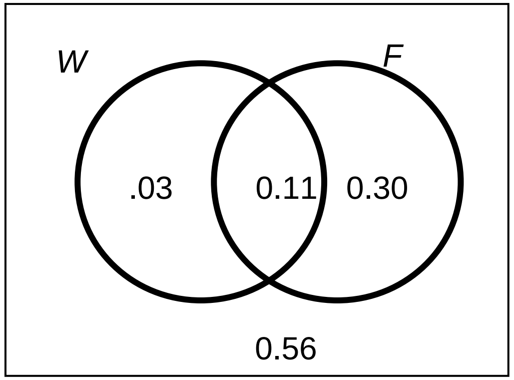
6. Write a brief report on the performance of the candidates. Your Team Leader will tell you when this is required. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.

7. Link Additional Objects with work relating to a question to those questions (a chain link appears by the relevant question number) – see scoris assessor Quick Reference Guide page 19-20 for instructions as to how to do this – this guide is on the Cambridge Assessment Support Portal and new users may like to download it with a shortcut on your desktop so you can open it easily! For AOs containing just formulae or rough working not attributed to a question, tick at the top to indicate seen but not linked. When you submit the script, *scoris* asks you to confirm that you have looked at all the additional objects. Please ensure that you have checked all Additional Objects thoroughly.

8. The schedule of dates for the marking of this paper is displayed under 'OCR Subject Specific Details' on the Cambridge Assessment Support Portal. It is vitally important that you meet these requirements. If you experience problems that mean you may not be able to meet the deadline then you must contact your Team Leader without delay.

	SECTION A			
Q1 (i)	$1000 \times 0.013 = 13$ Or $0.2 \times 65 = 13$ Or $0.2 \times 5 \times 13 = 13$	M1 A1 M1 for 0.2×65	**2**	Allow with or without working For MR $1000 \times 0.\ 13 = 130$ Allow M1A0 Allow M1A0 if extra terms added eg 1000×0.004 SC1 for $1000 \times 0.014 = 14$ For whole calculation
(ii)	Positive	B1	**1**	Allow +ve but NOT skewed to the right Do not allow 'positive correlation'
(iii)	Minimum value = 1500 Maximum value = 2500	B1 Without wrong working B1 Without wrong working	**2**	Exact answers only unless good explanation such as eg no road has length zero so min is eg 1501 SC1 for lower answer between 1499 and 1501 and upper between 2499 and 2501 Allow answer given as inequality
		TOTAL	**5**	
Q2 (i)	Either $\text{P(alphabetic order)} = \frac{1}{5} \times \frac{1}{4} \times \frac{1}{3} \times \frac{1}{2} \times \frac{1}{1} = \frac{1}{120}$ or $\text{P(alphabetic order)} = \frac{1}{5!} = \frac{1}{120} = 0.00833$	M1 for 5! or 120 or ${}^5P_5$ seen or product of correct fractions A1 CAO	**2**	Allow 0.0083 or 1/120 but not 0.008
(ii)	Either $\text{P(picks Austen and Bronte)} = \frac{2}{5} \times \frac{1}{4} = \frac{1}{10}$ or $\text{P(picks Austen and Bronte)} = \frac{1}{5} \times \frac{1}{4} \times 2 = \frac{1}{10}$ or $\text{P(picks Austen and Bronte)} = \frac{1}{\binom{5}{2}} = \frac{1}{10}$	M1 for denominators M1 for 2× *dep on correct denominators* A1 CAO Or M1 for $\binom{5}{2}$ or 10 M1 for $1/\binom{5}{2}$ A1 CAO	**3**	$1/{}_5P_2$ scores M1 also 1/20 oe scores M1 even if followed by further incorrect working $\binom{5}{2}$ seen as part of a binomial expression gets M0M0A0
		TOTAL	**5**	

Q3 (i)	$P(X = 0) = 0.75^6 = 0.178$	M1 for 0.75^6 A1 CAO	**2**	Or from tables 0.1780 Or 729/4096 Allow 0.18 with working
(ii)	$E(X) = np = 50 \times 0.178 = 8.9$	M1 for product A1 FT	**2**	FT their answer to (i) providing it's a probability NB A0 if subsequently rounded
		TOTAL	**4**	
Q4 (i)		G1 labelled linear scales on both axes G1 heights	**2**	Accept r or x for horizontal label and p or better for vertical including probability distribution Visual check only Allow G1G0 for points rather than lines Bars must not be wider than gaps for second G1 Condone vertical scale 1, 2, 3, 4, 5 and Probability (×) 1/18 as label BOD for height of $r = 0$ on vertical axis
(ii)	(A) If $X = 1$, possible scores are (1,2), (2,3), (3,4), (4,5), (5,6) and (2,1), (3,2), (4,3), (5,4), (6,5) (All are equally likely) so probability = $\frac{10}{36} = \frac{5}{18}$	M1 A1	**2**	Also M1 for a clear correct sample space seen with the ten 1's identified by means of circles or ticks oe soi. Must be convincing. No additional values such as 0,1 and 1,0 Do not allow ' just 10 ways you can have a difference of 1 so 10/36' or equivalent SC1 for possible scores are (1,2), (2,3), (3,4), (4,5), (5,6) so probability = 2 × 5 × 1/36 with no explanation for 2 ×
	(B) If $X = 0$, possible scores are (1,1), (2,2), (3,3), (4,4), (5,5), (6,6) so probability = $\frac{6}{36} = \frac{1}{6}$	B1	**1**	Also B1 for a clear correct sample space seen with the six 0's identified by means of circles or ticks oe soi. Must be convincing. No additional values. Allow both dice must be the same so probability = 6/36 = 1/6. Allow 1 × 1/6= 1/6 BOD
(iii)	Mean value of X = $0\times\frac{1}{6}+1\times\frac{5}{18}+2\times\frac{2}{9}+3\times\frac{1}{6}+4\times\frac{1}{9}+5\times\frac{1}{18}=1\frac{17}{18}=1.94$	M1 for Σrp (at least 3 terms correct) A1 CAO	**2**	Or 35/18 Division by 6 or other spurious factor gets MAX M1A0
		TOTAL	**7**	

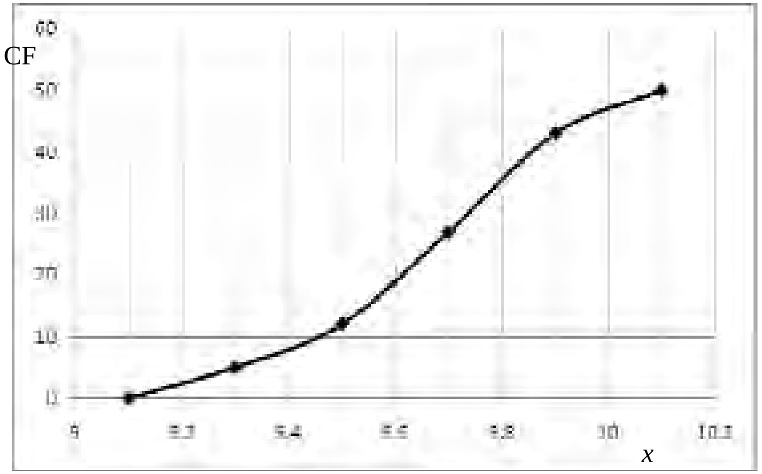
Q5 (i)		G1 for two labelled intersecting circles G1 for at least 2 correct probabilities. G1 for remaining correct probabilities	**3**	Allow labels such as P(W) and P(F) Allow other sensible shapes in place of circles
(ii)	P(W) × P(F) = 0.14 × 0.41 = 0.0574 ≠ P(W∩F) = 0.11 So not independent.	M1 for 0.41 × 0.14 A1 Condone dependent Must have full method www Must have either P(W∩F) or 0.11	**2**	Answer of 0.574 gets Max M1A0 Omission of 0.0574 gets M1A0 Max Or: P(W|F) = 0.11/0.41 = 0.268 ≠ P(W) (= 0.14) M1 for full working P(F|W) = 0.11/0.14 = 0.786 ≠ P(F) (= 0.41) M1 for full working No marks without correct working
(iii)	$P(W \mid F) = \frac{P(W \cap F)}{P(F)} = \frac{0.11}{0.41} = \frac{11}{41} = 0.268$ This is the probability that a randomly selected respondent works (part time), given that the respondent is female.	M1 for correct fraction A1 E1 For E1 must be in context – not just talking about events F and W	**3**	Allow 0.27 with working Allow 11/41 as final answer Condone 'if' or 'when' for 'given that' but not the words 'and' or 'because' or 'due to' for E1. E1 (independent of M1): the order/structure must be correct i.e. no reverse statement Allow 'The probability that a randomly selected female respondent works part time' oe
		TOTAL	**8**	

Q6 (i)	Mean $= \frac{1\times10+2\times40+3\times15+4\times5}{70} = \frac{155}{70} = 2.214$ S_{xx} = $1^2\times10+2^2\times40+3^2\times15+4^2\times5-\frac{155^2}{70} = 385-343.21 = 41.79$ s = $\sqrt{\frac{41.79}{69}}$ = 0.778	M1 A1 CAO M1 for Σfx^2 s.o.i. M1 for attempt at S_{xx} Dep on first M1 A1 CAO If 0.778 or better seen ignore previous incorrect working (calculator answer) Allow final answer to 2 sig fig (www)	**5**	For M1 allow sight of at least 3 double pairs seen from $1\times10+2\times40+3\times15+4\times5$ with divisor 70. Allow answer of 155/70 or 2.2 or 2.21 or 31/14 oe For 155/70 = eg 2.3 , allow A1 isw M1 for $1^2\times10+2^2\times40+3^2\times15+4^2\times5$ with at least three correct terms Using exact mean leads to S_{xx} = 41.79 , s=0.778, Using mean 2.214 leads to S_{xx} = 41.87 , s=0.779, Using mean 2.21 leads to S_{xx} = 43.11 and s = 0.790 Using mean 2.2 leads to S_{xx} = 46.2 and s = 0.818 Using mean 2 leads to S_{xx} = 105 and s = 1.233 All the above get M1M1A1 except the last one which gets M1M1A0 RMSD(divisor *n* rather than *n* – 1) =√(41.79/70) = 0.772 gets M1M1A0 Alternative method, award M1for at least 3 terms of and second M1 for all 4 terms of $(1-2.214)^2\times10+(2-2.214)^2\times40+(3-2.214)^2\times15$ $+(4-2.214)^2\times5(=41.79)$ NB Allow full credit for correct answers without working (calculator used)
(ii)	Mean would decrease Standard deviation would increase	B1 B1	**2**	Do not accept increase/decrease seen on their own – must be linked to mean and SD. Allow eg ‘It would skew the mean towards zero’ And eg ‘ It would stretch the SD’ SC1 for justified argument that standard deviation might either increase or decrease according to number with no eggs (n≤496 increase, n≥497 decrease)
		TOTAL	**7**	

	SECTION B			
Q7 (i)	$X \sim \mathrm{B}(20, 0.15)$ **(*A*)** *Either* $\mathrm{P}(\boldsymbol{X} = 1) = \binom{20}{1} \times 0.15^1 \times 0.85^{19} = 0.1368$ *or* $\mathrm{P}(X = 1) = \mathrm{P}(X \le 1) - \mathrm{P}(X \le 0)$ $= 0.1756 - 0.0388 = 0.1368$	M1 $0.15^1 \times 0.85^{19}$ M1 $\binom{20}{1} \times p^1 q^{19}$ A1 CAO OR: M2 for 0.1756 – 0.0388 A1 CAO	**3**	With $p + q = 1$ Allow answer 0.137 with or without working or 0.14 if correct working shown See tables at the website http://www.mei.org.uk/files/pdf/formula_book_mf2.pdf For misread of tables 0.3917 – 0.1216 = 0.2701 allow M1M1A0 also for 0.1304 – 0.0261 = 0.1043
	(*B*) $\mathrm{P}(X \ge 2) = 1 - \mathrm{P}(X \le 1)$ $= 1 - 0.1756 = 0.8244$	M1 for 1 – their 0.1756 A1 CAO	**2**	Provided 0.1756 comes from $\mathrm{P}(X{=}0) + \mathrm{P}(X{=}1)$ Allow answer 0.824 with or without working or 0.82 if correct working shown Point probability method: P(1) = 0.1368 , P(0) = 0.0388 So 1 - $\mathrm{P}(X{\le}1)$ = 1 - 0.1756 gets M1 then mark as per scheme M0A0 for $1 - \mathrm{P}(X \le 1) = 1 - 0.4049 = 0.5951$ For misread of tables 1 – 0.3917 = 0.6083 allow M1A1 also for 1 – 0. 1304 = 0.8696 provided consistent with part (*A*) OR M1A0 if formula used in part (*A*)

(ii)	Let $X \sim B(n, p)$ Let p = probability of a 'no-show' (for population) H_0: $p = 0.15$ H_1: $p < 0.15$ H_1 has this form because the hospital management hopes to reduce the proportion of no-shows.	B1 for definition of p B1 for H_0 B1 for H_1 E1 Allow correct answer even if H_1 wrong	**4**	Allow p = P(no-show) 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 of no-show, NOT just a sentence 'probability is 0.15' H_0 : p(no-show) = 0.15, H_1 : p(no-show) < 0.15 gets B0B1B1 Allow p=15%, allow θ or π and ρ but not x. However allow any single symbol <u>if defined</u> Allow $H_0 = p$=0.15, Do not allow H_0 : $P(X=x) = 0.15$, H_1 : $P(X=x) < 0.15$ Do not allow H_0: =0.15, =15%, P(0.15), p(0.15), p(x)=0.15, x=0.15 (unless x correctly defined as a probability) Do not allow H_1:$p \le 0.15$, Do not allow H_0 and H_1 reversed for B marks but can still get E1 Allow NH and AH in place of H_0 and H_1 For hypotheses given in words allow Maximum B0B1B1E1 Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.15 oe.
(iii)	$P(X \le 1) = 0.1756 > 5\%$ So not enough evidence to reject H_0. Not significant. Conclude that there is not enough evidence to indicate that the proportion of no-shows has decreased.	M1 for probability seen, but not in calculation for point probability M1 dep for comparison A1	**4**	Zero for use of point prob - $P(X = 1) = 0.1368$ Do <u>NOT</u> FT wrong H_1 Allow accept H_0, or reject H_1 Full marks only available if 'not enough evidence to…' oe mentioned somewhere Do not allow 'enough evidence to reject H_1' for final mark but can still get 3/4 Upper end comparison: 1 – 0.1756 = 0.8244 < 95% gets

	Note: use of critical region method scores M1 for region {0} M1 for 1 does not lie in critical region, then A1 E1 as per scheme	E1 dep for conclusion in context.		M2 then A1E1 as per scheme Line diagram method M1 for squiggly line between 0 and 1 with arrow pointing to left, M1 0.0388 seen on diagram from squiggly line or from 0, A1E1 for correct conclusion Bar chart method M1 for line clearly on boundary between 0 and 1 and arrow pointing to left, M1 0.0388 seen on diagram from boundary line or from 0, A1E1 for correct conclusion
(iv)	$6 < 8$ So there is sufficient evidence to reject H_0 Conclude that there is enough evidence to indicate that the proportion of no-shows appears to have decreased.	M1 for comparison seen A1 E1 for conclusion in context	**3**	Allow '6 lies in the CR' Do NOT insist on 'not enough evidence' here Do not FT wrong H_1:p>0.15 but may get M1 In part (iv) ignore any interchanged H_0 and H_1 seen in part (ii)
(v)	For $n \leq 18$, $P(X \leq 0) > 0.05$ so the critical region is empty.	E1 for $P(X \leq 0) > 0.05$ E1 indep for critical region is empty	**2**	E1 also for sight of 0.0536 Condone $P(X = 0) > 0.05$ or all probabilities or values, (but not outcomes) in table (for $n \leq 18$) > 0.05 Or 'There is no critical region' For second E1 accept 'H_0 would always be accepted' Do NOT FT wrong H_1 Use professional judgement - allow other convincing answers
		TOTAL	**18**	

<table>
<tr>
<td>Q8
(i)</td>
<td>
<table>
<tr><td>Upper Bound</td><td>9.1</td><td>9.3</td><td>9.5</td><td>9.7</td><td>9.9</td><td>10.1</td></tr>
<tr><td>Cumulative frequency</td><td>0</td><td>5</td><td>12</td><td>27</td><td>43</td><td>50</td></tr>
</table>


</td>
<td>B1 for cumulative frequencies

G1 for scales

G1 for labels

G1 for points (Provided plotted at correct UCB positions)

G1 for joining points

All G's dep on attempt at cumulative frequency but not cumulative fx's or other spurious values.</td>
<td>5</td>
<td>May be implied from graph. Condone omission of 0 at this stage.

Linear horizontal scale.
Linear vertical scale: 0 to 50
(no inequality scales - Not even <9.1, <9.3, <9.5 …)

Heating quality or x and Cumulative frequency or just CF or similar but not just frequency or fd nor cumulative fd

Plotted as (UCB, their cf). Ignore (9.1,0) at this stage. No midpoint or LCB plots.
Plotted within ½ small square

For joining all of 'their points' (line or smooth curve) AND now including (9.1,0) dep on previous G1

Mid point or LCB plots may score first three marks

Can get up to 3/5 for cum freq bars
Allow full credit if axes reversed correctly

Lines of best fit could attract max 4 out of 5.</td>
</tr>
<tr>
<td>(ii)</td>
<td>Median = 9.67</td>
<td>B1 FT
Allow answers between 9.66 and 9.68 without checking curve.
Otherwise check curve.</td>
<td>3</td>
<td>Based on 25th to 26th value on a cumulative frequency graph
ft their mid-point plot (not LCB's) approx 9.57 for m.p. plot Allow 9.56 to 9.58 without checking
B0 for interpolation</td>
</tr>
</table>

	Q1 = 9.51 Q3 = 9.83 Inter-quartile range = 9.83 – 9.51 = 0.32	B1 FT for Q3 or Q1 B1 FT for IQR providing both Q1 and Q3 are correct Allow answers between 9.50 and 9.52 and between 9.82 and 9.84 without checking curve. Otherwise check curve.		Based on 12th to 13th and 37th to 38th values on a cumulative frequency graph ft their mid -point plot (not LCB's) approx Q1 = 9.42; Q3 = 9.73 Allow 9.41 to 9.43 and 9.72 to 9.74 without checking B0 for interpolation Allow correct IQR from graph if quartiles not stated Lines of best fit: B0 B0 B0 here.
(iii)	Lower limit 9.51 – 1.5 × 0.32 = 9.03 Upper limit 9.83 + 1.5 × 0.32 = 10.31 Thus there are no outliers in the sample.	B1 FT their Q_1, IQR B1 FT their Q_3, IQR E1 NB E mark dep on both B marks	**3**	Any use of <u>median</u> ± 1.5 IQR scores B0 B0 E0 If FT leads to limits above 9.1 or below 10.1 then E0 No marks for ± 2 or 3 IQR In this part FT their values from (ii) if sensibly obtained (eg from LCB plot) or lines of best fit, but not from location ie 12.5, 37.5 or cumulative fx's or similar. For use of mean ± 2s, Mean = 9.652, s = 0.235, Limits 9.182, 10.122 gets M1 for correct lower limit, M1 for correct upper limit, zero otherwise, but E0 since there could be outliers using this definition
(iv)	(*A*) P(All 3 more than 9.5) = $\frac{38}{50}\times\frac{37}{49}\times\frac{36}{48} = 0.4304$ (=50616/117600 = 2109/4900)	M1 for 38/50 × (triple product) M1 for product of remaining fractions A1 CAO	**3**	$(38/50)^3$ which gives answer 0.4389 scores M1M0A0 so watch for this. M0M0A0 for binomial probability including 0.76^{100} but $^3C_0\times0.24^0\times0.76^3$ still scores M1 $(k/50)^3$ for values of k other than 38 scores M0M0A0 $\frac{k}{50}\times\frac{(k-1)}{49}\times\frac{(k-2)}{48}$ for values of k other than 38 scores M1M0A0 Correct working but then multiplied or divided by some factor scores M1M0A0

				Accept 0.43 with working and 0.430 without working Or $\binom{38}{3}/\binom{50}{3}$ = 2109/4900 = 0.4304 Allow unsimplified fraction as final answer 50616/117600
	(B) P(At least 2 more than 9.5) $= 3\times\frac{38}{50}\times\frac{37}{49}\times\frac{12}{48}+0.4304$ = 3 × 0.1435 + 0.4304 = 0.4304 + 0.4304 = 0.861 (=101232/117600 = 4218/4900 = 2109/2450) OR P(At least 2 more than 9.5) = 1 – (P(0) + P(1)) $= 1-\left[\left(\frac{12}{50}\times\frac{11}{49}\times\frac{10}{48}\right)+\left(3\times\frac{12}{50}\times\frac{11}{49}\times\frac{38}{48}\right)\right]$ = 1 – [0.01122 + 0.12796] = 1 – 0.13918 = 0.861	M1 for product of 3 correct fractions seen M1 for 3 × a sensible triple or sum of 3 sensible triples M1 indep for + 0.4304 FT (providing it is a probability) A1 CAO M1 for 12/50×11/49×38/48 M1 for 3 × a sensible triple or sum of 3 sensible triples M1 dep on both previous M1's for 1 –[0.01122 + 0.12796] A1 CAO	**4**	Or $\binom{38}{2}\binom{12}{1}/\binom{50}{3}$=0.4304 gets first two M1M1's SC1 for $3\times\frac{38}{50}\times\frac{38}{50}\times\frac{12}{50}$ or other sensible triple and SC2 if this + their 0.4304 (= 0.8549) Allow 0.86 or 2109/2450 or 4218/4900, but only M3A0 for other unsimplified fractions Use of 1 – method 'with replacement' SC1 for $3\times\frac{12}{50}\times\frac{12}{50}\times\frac{38}{50}$ SC2 for whole of 1 - $3\times\frac{12}{50}\times\frac{12}{50}\times\frac{38}{50}+\frac{12}{50}\times\frac{12}{50}\times\frac{12}{50}$ (= 1 – (0.1313 + 0.0138) = 1 – 0.1451 = 0.8549)
		TOTAL	**18**	

NOTE RE OVER-SPECIFICATION OF ANSWERS

If answers are grossly over-specified (see instruction 8), 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.

Question			Answer	Marks	Guidance	
1	(i)		P(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)	$(30/50)^3$ = 0.216 scores M1M0A0 $\frac{k}{50}\times\frac{(k-1)}{49}\times\frac{(k-2)}{48}$ for values of k other than 30 scores M1M0A0 Zero for binomial unless simplifies to $(3/5)^3$
				M1	For product of other two fractions	Correct working but then multiplied or divided by some factor scores M1M0A0
			OR $\binom{30}{3}/\binom{50}{3}$ = 4060/19600 = 29/140 = 0.2071 M2 for the complete method	A1 **[3]**	CAO SC2 for P(All red) = 0.0582	Accept 0.21 with working and 0.207 without working Allow unsimplified fraction as final answer 24360/117600 oe
1	(ii)		P(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 – $(30/50)^3$ – $(20/50)^3$ = 1 – 0.216 – 0.064 = 0.72, providing consistent with (i) . If not consistent with (i) M0M0A0
			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)	
			OR	A1 **[3]**	CAO	Allow 0.73 with working Allow unsimplified fraction as final answer 86400/117600 oe
			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 M1 for $3\times(30/50)^2\times(20/50)$ or $3\times(30/50)\times(20/50)^2$ and second M1 for sum of both if = 0.72 If not consistent with (i) M0M0A0

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

Question			Answer	Marks	Guidance	
3	**(i)**		X ~ B(30, 0.85)	M1	For $0.85^{29} \times 0.15^1 = 0.0013466$	
			$P(X = 29) = \binom{30}{29} \times 0.85^{29} \times 0.15^1 = 30 \times 0.0013466 = 0.0404$	M1	For $\binom{30}{29} \times p^{29} \times q^1$	With $p + q = 1$
				A1 **[3]**	CAO	Allow 0.04 www If further working (EG P(X=29) –P(X=28)) give M2A0
3	**(ii)**		$P(X = 30) = 0.85^{30} = 0.0076$	M1	For 0.85^{30}	
			$P(X \geq 29) = 0.0404 + 0.0076 = 0.0480$	M1	For P(X = 29) + P(X = 30) (not necessarily correct, but both attempts at binomial, including coefficient in (i))	Allow eg 0.04+0.0076=0.0476 Allow 0.05 with working
				A1 **[3]**	CAO	
3	**(iii)**		Expected number = 10 × 0.0480 = 0.480	M1	For 10 × their **(ii)**	**provided (ii) between 0 and 1**
				A1 **[2]**	FT their **(ii)** but if answer to (ii) leads to a whole number for (iii) give M1A0	Do not allow answer rounded to 0 or 1.

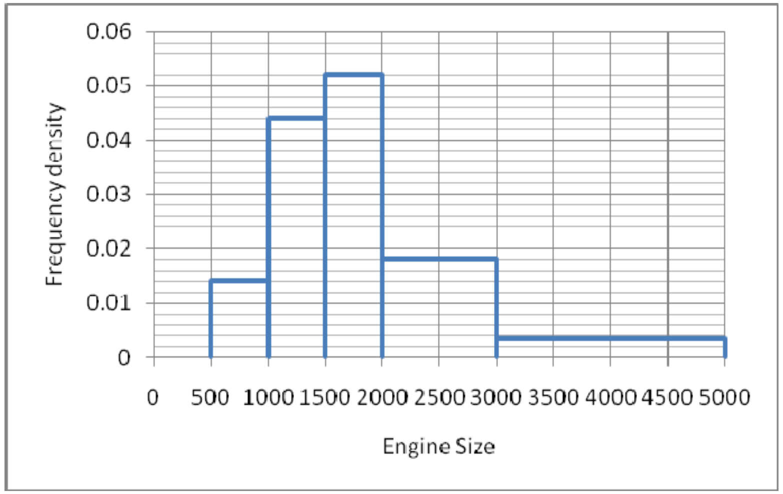
Question			Answer	Marks	Guidance	
4	(i)	(*A*)	P(third selected) = $0.92^2 \times 0.08 = 0.0677$ Or = 1058/15625	M1 M1 A1 [3]	For 0.92^2 For $p^2 \times q$ CAO SC1 for 'without replacement' method 92/100×91/99×8/98 =0.0690	 With $p + q = 1$ With no extra terms Allow 0.068 but not 0.067 nor 0.07
4	(i)	(*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 'without replacement' method	With no extra terms Allow 0.141 to 0.142 and allow 0.14 with working
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 answer of 0.81 or better from P(1) + P(2) + ... , 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			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:$p\geq 0.05$, 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 $1- P(X \leq 3)$ 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

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} 4 lies in the critical region, so significant,	(A1)	CAO for critical region and significant oe	Condone {4,5 ..}, $X \geq 4$, oe but not $P(X \geq 4)$
			There is evidence to suggest that the proportion of faulty frames has increased.	(E1)		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(i)</td><td></td><td>

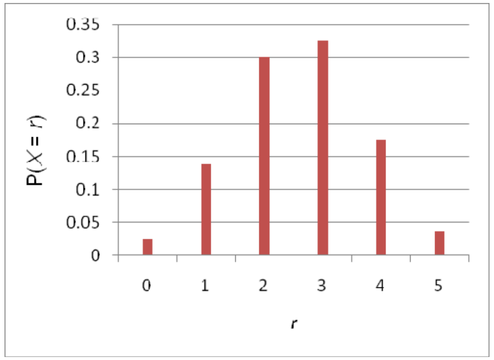
Engine size	Frequency	Group width	Frequency density
$500 \le x \le 1000$	7	500	0.014
$1000 < x \le 1500$	22	500	0.044
$1500 < x \le 2000$	26	500	0.052
$2000 < x \le 3000$	18	1000	0.018
$3000 < x \le 5000$	7	2000	0.0035

</td><td>M1</td><td>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</td></tr>
<tr><td></td><td></td><td></td><td>
</td><td>A1
G1(L1)</td><td>For fd's all correct
linear scales on both axes and label on vertical axis
Label required on vert axis IN RELATION 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</td></tr>
<tr><td></td><td></td><td></td><td><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
Frequency polygons MAX M1A1G0G0G0</td><td>G1(W1)</td><td>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 500≤S<1000, etc but allow if a clear horizontal linear scale is also given.</td></tr>
</table>

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)**		Do not know exact highest and lowest values so cannot tell what the midrange is. **<u>OR</u>** No and a counterexample to show it may not be 2750 **<u>OR</u>** (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 value could be 5000 and lowest could be 500 therefore midrange could be 2750' NO mark if incorrect calculation Sight of 1750 AND 3000 (min and max of midrange) scores E1
6	**(iii)**		Mean = $\dfrac{(750\times7)+(1250\times22)+(1750\times26)+(2500\times18)+(4000\times7)}{80}$ $=\dfrac{151250}{80}=1891$ $\Sigma x^2 f=(750^2\times7)+(1250^2\times22)+(1750^2\times26)+(2500^2\times18)+(4000^2\times7)$ = 3937500 + 34375000 + 79625000 + 112500000 + 112000000 =342437500 $Sxx=342437500-\dfrac{151250^2}{80}=56480469$ $s=\sqrt{\dfrac{56480469}{79}}=\sqrt{714943}=846$ 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 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 S_{xx} given For sum of at least 3 correct multiples fx^2 Allow M1 for anything which rounds to 342400000 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

Question			Answer	Marks	Guidance
6	(iv)		$\overline{x} - 2s = 1891 - (2\times 846) = 199$ Allow 200	M1	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 × standard deviation', do NOT award M1 No marks in (iv) unless using $\overline{x} + 2s$ or $\overline{x} - 2s$
			$\overline{x} + 2s = 1891 + (2\times 846) = 3583$ Allow 3580 or 3600	A1	For both (FT) Do **NOT** penalise over specification here as it is not the final answer
			So there are probably some outliers	E1 **[3]**	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 cm^3 = 25/80 × 2.5 million = 781250 So duty raised = 781250 × £1000 = £781 million	M1 M1 indep A1 **[3]**	For 25/80× 2.5 million or (18+7) /80× 2.5 million For something × £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 cm^3 might be reduced due to the additional duty.	E1 **[1]**	Allow any other reasonable suggestion Condone 'sample may not be representative' Allow 'sample is not of **NEW** cars'

Question			Answer	Marks	Guidance
7	(i)		$P(X = 0) = 0.4 \times 0.5^4 = 0.025$ **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 term (not multiplied or divided by anything) For $4 \times 0.4 \times 0.5^4$ Allow 4×0.025 Watch out for incorrect methods such as (0.4/4) 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 axes Dep on attempt at vertical line chart. Accept P on vertical axis 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 > 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

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)		$E(X) = (0\times0.025) + (1\times0.1375) + (2\times0.3) + (3\times0.325) + (4\times0.175) + (5\times0.0375)$ $= 2.6$ $E(X^2) = (0\times0.025) + (1\times0.1375) + (4\times0.3) + (9\times0.325) + 16\times0.175) + (25\times0.0375) = 0 + 0.1375 + 1.2 + 2.925 + 2.8 + 0.9375 = 8$ $\text{Var}(X) = 8 - 2.6^2$ $= 1.24$	M1 A1 M1* M1* dep A1 **[5]**	For Σrp (at least 3 terms correct) CAO For Σr^2p (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 $\Sigma p(x-\mu)^2$ (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)		P(Total of 3) $= (3\times0.325\times0.025^2) + (6\times0.3\times0.1375\times0.025) + 0.1375^3 = 3 \times 0.000203 + 6 \times 0.001031 + 0.002600 = 0.000609 + 0.006188 + 0.002600 = 0.00940$ $(= 3\times13/64000 + 6\times33/32000 + 1331/512000)$	M1 M1 M1 A1 **[4]**	For decimal part of first term 0.325×0.025^2 For decimal part of second term $0.3\times0.1375\times0.025$ 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($X \le 3$)
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($X \ge 3$) = 1 – P($X \le 2$) > 5%
P($X \ge 4$) = 1 – P($X \le 3$) < 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($X \le k - 1$) = P($X \le 3$)
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

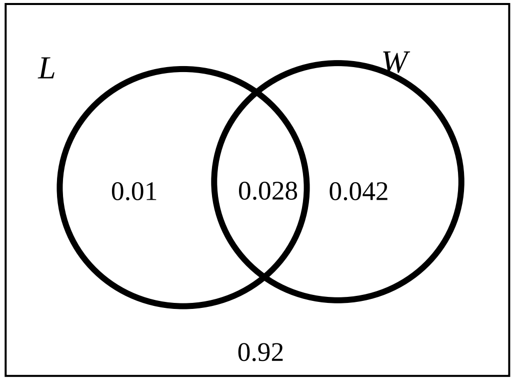
Bar chart method
B1 for line clearly on boundary between 3 and 4 or within 4 block exclusively (ie just one line), B1*dep* for arrow pointing to right, M1 0.0109 seen on diagram from boundary line or from 8, A1E1 for correct conclusion.

Using P(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 $P(X \geq 4)$.

Question			Answer	Marks	Guidance	
1	(i)		Positive	B1 **[1]**	CAO	
1	(ii)		Mean = 5.064 allow 5.1 with working 126.6/25 or 5.06 without SD = 1.324 allow 1.3 with working or 1.32 without	B1 B2 **[3]**	 Allow B1 for RMSD = 1.297 or var =1.753 or MSD = 1.683	 Also allow B1 for $Sxx = 42.08$ or for $\Sigma x^2 = 683$ SC1 for both mean = 50.64 and SD = 13.24 (even if over-specified)
1	(iii)		$\bar{x} - 2s = 5.064 - 2 \times 1.324 = 2.416$ $\bar{x} + 2s = 5.064 + 2 \times 1.324 = 7.712$ So there is an outlier.	B1FT M1 A1FT E1 **[4]**	FT their mean and sd for $\bar{x} + 2s$ but withhold final E mark if their limits mean that there are no outliers. For upper limit Incorrect statement such as 7.6 and 8.1 are outliers gets E0 Do not award E1 if calculation error in upper limit	For use of quartiles and IQR $Q_1 = 3.95$; $Q_3 = 6.0$; IQR = 2.05 3.95 – 1.5(2.05) gets M1 Allow other sensible definitions of quartiles 6.0 + 1.5(2.05) gets M1 Limits 0.875 and 9.075 So there are no outliers NB do not penalise over-specification here as not the final answer but just used for comparison. FT from SC1
2	(i)		<table><tr><td>r</td><td>2</td><td>3</td><td>4</td><td>5</td></tr><tr><td>P($X = r$)</td><td>$3k$</td><td>$8k$</td><td>$15k$</td><td>$24k$</td></tr></table> $3k + 8k + 15k + 24k = 1$ $k = 0.02$	B1 M1 A1 **[3]**	For correct table (ito k or correct probabilities 0.06, 0.16, 0.30, 0.48) or $k = 1/50$ (with or without working)	 For their four multiples of k added and =1. Allow M1A1 even if done in part **(ii)** – link part **(ii)** to part **(i)**

Question			Answer	Marks	Guidance	
2	(ii)		$E(X) = (2\times0.06)+(3\times0.16)+(4\times0.30)+(5\times0.48)=4.2$	M1	For Σrp (at least 3 terms correct Provided 4 reasonable probabilities seen.	If probs wrong but sum = 1 allow full marks here. If sum ≠ 1 allow max M1A0M1 M0A0 (provided all probabilities between 0 and 1)
			or 21/5	A1	cao	Or ito k NB $E(X) = 210k$, $E(X^2) = 924k$ gets M1A0M1M0A0. $E(X) = 210k$, $\text{Var}(X) = 924k - (210k)^2$ gets M1A0M1M1A0.
			$E(X^2) = (4\times0.06)+(9\times0.16)+(16\times0.30)+(25\times0.48)=18.48$	M1	For Σr^2p (at least 3 terms correct)	
			$\text{Var}(X) = 18.48 - 4.2^2$	M1	dep for – their $E(X)^2$	
			$= 0.84 = 21/25$	A1	FT their $E(X)$ provided $\text{Var}(X) > 0$ (and of course $E(X^2)$ is correct)	Use of $E(X-\mu)^2$ gets M1 for attempt at $(x-\mu)^2$ should see $(-2.2)^2$, $(-1.2)^2$, $(-0.2)^2$, 0.8^2, (if $E(X)$ wrong FT their $E(X)$) (all 4 correct for M1), then M1 for $\Sigma p(x-\mu)^2$ (at least 3 terms correct with their probabilities) Division by 4 or other spurious value at end gives max M1A1M1M1A0, or M1A0M1M1A0 if $E(X)$ also divided by 4. Unsupported correct answers get 5 marks
				[5]		
3	(i)		$P(L\cap W)=P(L\mid W)\times P(W)=0.4\times0.07=0.028$	M1	For $P(L\mid W)\times P(W)$	
				A1 **[2]**	cao	

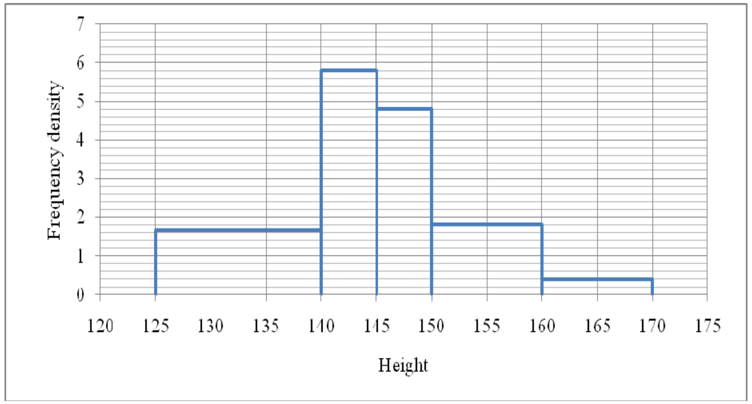
Question			Answer	Marks	Guidance	
3	(ii)			B1 B1 B1 **[3]**	For two labelled intersecting circles For at least 2 correct probabilities. For remaining probabilities	FT their 0.028 provided < 0.038
3	(iii)		$P(L \cap W) = 0.028, P(L) \times P(W) = 0.038 \times 0.07 = 0.00266$ Not equal so not independent	M1 A1 E1* dep on M1 **[3]**	For correct use of $P(L) \times P(W)$ If P(L) wrong, max M1A0E0. No marks if P(W) wrong For 0.00266 Allow 'they are dependent' Do not award E1 if $\mathrm{P}(L \cap W)$wrong	Or EG $\mathrm{P}(L \mid W) = 0.4, \mathrm{P}(L) = 0.038$ Not equal so not independent M1 is for comparing with some attempt at numbers $\mathrm{P}(L \mid W)$ with $\mathrm{P}(L)$, A1 for 0.038 If P(L) wrong, max M1A0E0
4	(i)		$\binom{11}{3}$ = 165	M1 A1 **[2]**	Seen Cao	

Question			Answer	Marks	Guidance	
4	(ii)		$\dfrac{\binom{5}{2}\times\binom{6}{1}}{\binom{11}{3}}+\dfrac{\binom{5}{3}\times\binom{6}{0}}{\binom{11}{3}}=\dfrac{60}{165}+\dfrac{10}{165}=\dfrac{70}{165}=\dfrac{14}{33}=0.424$	M1	For intention to add correct two fractional terms	**Or** For attempt at correct two terms
			Alternative $1-\text{P}(1\text{ or }0)=1-3\times\dfrac{5}{11}\times\dfrac{6}{10}\times\dfrac{5}{9}-\dfrac{6}{11}\times\dfrac{5}{10}\times\dfrac{4}{9}$ $=1-\dfrac{5}{11}-\dfrac{4}{33}=\dfrac{14}{33}$ M1 for 1 – P(1 or 0) , M1 for first product, M1 for ×3, M1 for second product, A1	M1 M1	For numerator of first term For numerator of sec term Do not penalise omission of $\binom{6}{0}$	For prod of 3 correct fractions =4/33 For whole expression ie $3\times\dfrac{5}{11}\times\dfrac{4}{10}\times\dfrac{6}{9}\left(=\dfrac{4}{11}\right)(= 3 \times 0.1212\ldots)$
				M1	For correct denominator	For attempt at $\dfrac{5}{11}\times\dfrac{4}{10}\times\dfrac{3}{9}\left(=\dfrac{2}{33}\right)$
				A1 **[5]**	cao	cao Use of binomial can get max first M1
5	(i)		$\left(\dfrac{5}{6}\right)^2\times\dfrac{1}{6}=\dfrac{25}{216}\ (= 0.116)$	M1	For 5/6 (or 1 – 1/6) seen	If extra term or whole number factor present give M1M0A0
				M1 A1 **[3]**	For whole product cao	Allow 0.12 with working
5	(ii)		$1-\left(\dfrac{5}{6}\right)^{10}=1-0.1615=0.8385$	M1	For $(5/6)^{10}$ (without extra terms)	Allow 0.838 or 0.839 without working and 0.84 with working. For addition P(X = 1) +…+ P(X = 10) give M1A1 for 0.84 or better, otherwise M0A0
				A1 **[2]**	cao	

Question			Answer	Marks	Guidance	
6	(i)		4 + ½ of 18 = 4 + 9 =13	M1 A1 **[2]**	For ½ of 18 cao	 13/100 gets M1A0
6	(ii)		(Median) = 50.5th value Est = 140 + $\left(\frac{25.5}{29}\right)\times 5$ or = 140 + $\left(\frac{50.5-25}{54-25}\right)\times 5$ = 144.4	M1 M1 A1 **[3]**	For 50.5 seen For attempt to find this value	SC2 for use of 50th value leading to Est = 140 + (25 /29 × 5) = 144.3 (SC1 if over-specified) or Est = 145 – $\left(\frac{3.5}{29}\right)\times 5$ = 144.4 NB no marks for mean = 144.35 NB Watch for over-specification

Question		Answer	Marks	Guidance	
6	(iii)	(see table and histogram below)	M1	For fd's - at least 3 correct Accept any suitable unit for fd such as eg freq per cm.	M1 can be also be gained from freq per 10 – 16.7, 58, 48, 18, 4 (at least 3 correct) or freq per 5 – 8.35, 29, 24, 9, 2
			A1	correct to at least one dp allow 1.66 but not 1.6 for first fd	for all correct. If fd not explicitly given, M1 A1 can be gained from all heights correct (within one square) on histogram (and M1A0 if at least 3 correct)
			G1	linear scales on both axes and label on vertical axis	Linear scale and label on vertical axis IN RELATION to first M1 mark ie fd or frequency density or if relevant freq/10, etc (NOT eg fd/10). However allow scale given as fd×10, or similar Accept f/w or f/cw (freq/width or freq/class width) Can also be gained from an accurate key G0 if correct label but not fd's.
			W1	width of bars	Must be drawn at 125, 140 etc NOT 124.5 or 125.5 etc NO GAPS ALLOWED Must have linear scale. No inequality labels on their own such as 125≤S<140, etc but allow if a clear horizontal linear scale is also given. Ignore horizontal label.
			H1	height of bars	Height of bars – must be linear vertical scale. FT of heights dep on at least 3 heights correct and all must agree with their

Height	Frequency	Group width	Frequency density
$125 \le x \le 140$	25	15	1.67
$140 < x \le 145$	29	5	5.80
$145 < x \le 150$	24	5	4.80
$150 < x \le 160$	18	10	1.80
$160 < x \le 170$	4	10	0.40



Question			Answer	Marks		Guidance
				[5]		fds If fds not given and at least 3 heights correct then max M1A0G1W1H0 Allow restart with correct heights if given fd wrong (for last three marks only)
6	(iv)		4 boys 0.6×15 = 9 girls So 5 more girls	 M1 A1 A1 [3]	 For 0.6×15 For 9 girls cao	 Or $45 \times 0.2 = 9$ (number of squares and 0.2 per square)
6	(v)		Frequencies and midpoints for girls are Height: 132.5, 142.5, 147.5, 155, 167.5 Frequency: 18, 23, 31, 19, 9	B1 B1	For at least three frequencies correct At least three midpoints correct	 No further marks if not using midpoints
			So mean = $\frac{(132.5\times18)+(142.5\times23)+(147.5\times31)+(155\times19)+(167.5\times9)}{100}$ $=\frac{(2385)+(3277.5)+(4572.5)+(2945)+(1507.5)}{100}$	M1 M1* Dep on M1	For attempt at $\sum xf$ For division by 100	For sight of at least 3 xf pairs
			= 146.9 (Exact answer 146.875)	A1 [5]	Cao NB Watch for over-specification	Allow answer 146.9 or 147 but not 150 NB Accept answers seen without working (from calculator) Use of 'not quite right' midpoints such as 132.49 or 132.51 etc can get B1B0M1M1A0

Question			Answer	Marks	Guidance	
7	(i)	(*A*)	$X \sim B(10, 0.35)$ P(5 accessing internet) = $\binom{10}{5} \times 0.35^5 \times 0.65^5$	M1 M1	or $0.35^5 \times 0.65^5$ For $\binom{10}{5} \times p^5 \times q^5$	 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	
7	(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.
7	(i)	(*C*)	E(X) = np = 10 × 0.35 = 3.5	M1 A1 **[2]**	For 10 × 0.35 cao	If any indication of rounding to 3 or 4 allow M1A0

Question			Answer	Marks	Guidance	
7	(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	For 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

Question			Answer	Marks	Guidance	
			H_1: $p \neq 0.35$	B1	For 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	For 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} So not significant Conclude that there is not enough evidence to indicate that the probability is different.	M1* dep A1* E1* dep on A1 **[9]**	cao dep on at least one correct comparison with 2.5%	No marks if CR not justified Condone {0,1,2, 12, … 20}, $X \le 2$, $X \ge 12$, oe but not P($X \le 2$) etc 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
7	(iii)		0.0022 < 2.5% So reject H_o, Significant. Conclude that there is enough evidence to indicate that the probability is different.	B1 E1* dep **[2]**	For either reject H_o or significant, dep on correct comparison 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%.

APPENDIX

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.

Additional notes re Q7 part ii

Comparison with 97.5% method

If 97.5% seen anywhere then
B1 for P($X \leq 9$)
B1 for 0.8782
M1* for comparison with 97.5% dep on second B1
A1* for not significant oe
E1*

Smallest critical region method:

Smallest critical region that 10 could fall into is {10,11,12,13,14,15, 16, 17, 18,19,20} **gets B1 and has size 0.1218 gets B1, This is > 2.5% gets M1*, A1*, E1* as per scheme**
NB These marks only awarded if 10 used, not other values.

Use of *k* method with no probabilities quoted:

This gets zero marks.

Use of *k* method with one probability quoted:

Mark as per scheme

Line diagram method and Bar chart method

No marks unless correct probabilities shown on diagram, then mark as per scheme.

Upper tailed test done with H_1: p>0.35

Hyp gets max B1B1B0E0
If compare with 5% give SC2 for $P(X \geq 10) = 1 – 0.8782 = 0.1218 > 5\%$ and SC1 for final conclusion (must be 'larger than' not 'different from')
If compare with 2.5% no further marks B0B0M0A0E0

Lower tailed test done with H_1: p<0.35

No marks out of last 5.

Question			Answer	Marks	Guidance	
1	(i)		Mean $= \dfrac{24940}{100} = 249.4\text{g or } 249\text{g}$	B1	Ignore units	CAO NB 249.40 gets B0 for over-specification
			$Sxx = 6240780 - \dfrac{24940^2}{100} = 20744$	M1	For Sxx	M1 for 6240780 - 100 × their mean^2 BUT NOTE M0 if their $S_{xx} < 0$
			$s = \sqrt{\dfrac{20744}{99}} = \sqrt{209.53} = 14.4751 = 14.5\text{g}$	A1 **[3]**	CAO ignore units	For s^2 of 210 (or better) allow M1A0 with or without working For RMSD of 14.4 (or better) allow M1A0 provided working seen For RMSD^2 of 207 (or better) allow M1A0 provided working seen Allow 14.48 but NOT 14.47
1	(ii)		New mean = (0.9 × 249.4) – 15 = 209.5g	B1	FT their mean provided answer is positive	If candidate 'starts again' only award marks for CAO Allow 209
			New sd = 0.9 × 14.48 = 13.03g	M1 A1 **[3]**	FT their sd FT Allow 13.0 to 13.1	Or for $0.9^2 \times 14.5^2$ Deduct at most 1 mark overall in whole question for over-specification of Mean and 1 mark overall for SD

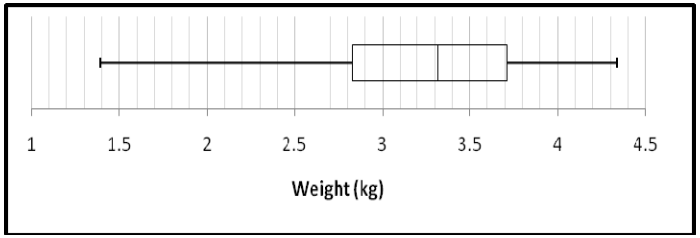
Question			Answer	Marks	Guidance	
2	(i)		$3\times\frac{5}{10}\times\frac{4}{9}\times\frac{5}{8}=\frac{300}{720}=\frac{5}{12}$ = (0.4167)	M1	For 5/10 × 4/9	Correct working but then multiplied or divided by some factor scores M1M1M0A0
				M1	For × 5/8	Zero for binomial Allow M2 for equivalent triple such as $\frac{5}{10}\times\frac{5}{9}\times\frac{4}{8}$
				M1	For 3 × triple product	Or 3 separate equal triplets added
				A1	CAO (Fully simplified)	Answer must be a fraction
				[4]		
			Or $\frac{\binom{5}{2}\times\binom{5}{1}}{\binom{10}{3}}=\frac{10\times5}{120}=\frac{5}{12}$	M1*	For $\binom{5}{2}\times\binom{5}{1}$	Seen
				M1*	For $\binom{10}{3}$	Seen
				M1* dep	For whole fraction	Correct working but then multiplied or divided by some factor scores M1M1M0A0
				A1	CAO (Fully simplified)	
2	(ii)		$4\times\frac{7}{12}\times\left(\frac{5}{12}\right)^3+\left(\frac{5}{12}\right)^4$	M1FT	For first probability	Allow ${}^4C_3$
				M1FT	For $(5/12)^4$	
				M1FT	For sum of both correct probabilities	Provided sum <1
			$=0.169+0.030=0.199$ Or $=\frac{875}{5184}+\frac{625}{20736}=\frac{1375}{6912}$	A1	CAO Do not allow 0.2, unless fuller answer seen first	Alternative for 1- (P(0)+P(1)+P(2)) allow M1FT for two 'correct' probs, M1 for sum of three 'correct', M1 for 1 – answer, A1 CAO
				[4]		

Question			Answer	Marks	Guidance	
3	**(i)**		X ~ B(50, 0.1) P(5 underweight) = $\binom{50}{5} \times 0.1^5 \times 0.9^{45}$ = 0.1849	M1 M1 A1 **[3]**	For $0.1^5 \times 0.9^{45}$ For $\binom{50}{5} \times p^5 \times q^{45}$ CAO	With p **+** $\boldsymbol{q}$ **= 1** Also for 2118760 × 8.73 × 10^{-8} Allow 0.185 or better NB 0.18 gets A0
3	**(ii)**		X ~ B(20, 0.1) P(X ≥ 1) = 1 – P(X = 0) = 1 – 0.1216 = 0.8784	M1 A1 **[2]**	For 0.1216 CAO	Allow M1 for 0.9^{20} Allow 0.878 or better See tables at the website http://www.mei.org.uk/files/pdf/formula_book_mf2.pdf
3	**(iii)**		E(X) = 48 × 0.8784 = 42.16 (= 42.2)	M1 A1 **[2]**	FT their probability from part (ii)	If any indication of rounding to 42 or 43 or to another integer on FT allow M1A0 SC1 for 48 × their p giving an integer answer. NB 0.6083 in (ii) leads to 29.20

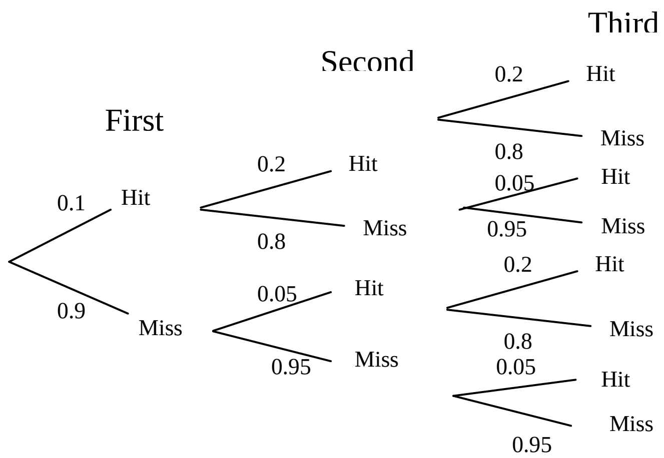
Question			Answer	Marks	Guidance	
4	(i)		$\text{P}(X = 15) = \frac{3}{6}\times\frac{2}{5}\times\frac{1}{4}$	M1	For product of three correct fractions	
			$= = \frac{6}{120} = \frac{1}{20} = 0.05$ **Or** $\frac{1}{{}_6C_3} = \frac{1}{20} = 0.05$ **Or** $\frac{3!\times 3!}{6!} = \frac{1}{20} = 0.05$	A1 **[2]**	NB ANSWER GIVEN NB 1 – (0.45 + 0.45 + 0.05) = 0.05 scores M0A0	Full marks for $3!\times\frac{1}{6}\times\frac{1}{5}\times\frac{1}{4} = \frac{6}{120} = 0.05$ Allow 3×2 in place of 3! SC1 for $6\times\frac{1}{6}\times\frac{1}{5}\times\frac{1}{4} = \frac{6}{120} = 0.05$
4	(ii)		E(X) = (15 × 0.05) + (1010 × 0.45) + (2005 × 0.45) + (3000 × 0.05)	M1	For Σrp (at least 3 terms correct)	
			= 1507.5 so 1508 (4sf)	A1	CAO	Allow 1507, 1510, 1507.5, 1507.50 or 3015/2
			E(X^2) = (15^2 × 0.05) + (1010^2 × 0.45) + (2005^2 × 0.45) + (3000^2 × 0.05) = 2718067.5	M1	For $\Sigma r^2 p$ (at least 3 terms correct)	Use of $E(X-\mu)^2$ gets M1 for attempt at $(x-\mu)^2$ should see $(-1492.5)^2$, $(-497.5)^2$, 497.5^2, 1492.5^2, (if E(X) wrong FT their E(X)) (all 4 correct for M1), then M1 for $\Sigma p(x-\mu)^2$ (at least 3 terms correct with their probabilities) Division by 4 or other spurious value at end gives max M1A1M1M1A0, or M1A0M1M1A0 if E(X) also divided by 4. Unsupported correct answers get 5 marks
			Var (X) = $2718067.5 - (1507.5)^2$	M1	dep for – their $E(X)^2$	
			= 445511.25 so 445500 (4sf)	A1	FT their E(X) provided Var(X) > 0 (and of course $E(X^2)$ is correct)	Allow 446000
				[5]		

Question			Answer	Marks	Guidance	
5	(i)		Because if people cannot make a correct identification, then the probability that they guess correctly will be 0.5 For 'equally likely to guess right or wrong' or 'two outcomes with equal probability' or '50:50 chance of success' or 'right one in two occasions on average' or 'two (equally likely) outcomes' etc	E1 E1 **[2]**	For idea of a guess or 'chosen at random' For idea of two outcomes	NB The question includes the sentence 'She suspects that people do no better than they would by guessing.', so this on its own does not get the mark for the idea of a guess
5	(ii)		'Because people may do better than they would by guessing' or similar	B1 **[1]**	For idea of selecting correctly /identifying /knowing	No marks if answer implies that it is because there are over half in the sample who make a correct identification
5	(iii)		$P(X \geq 13) = 1 - P(X \leq 12) = 1 - 0.8684 = 0.1316$ **NB PLEASE ANNOTATE THE TOP AND BOTTOM OF THE EXTRA PAGE IF NOT USED**	M1 B1*	For notation $P(X \geq 13)$ or $P(X > 12)$ or $1 - P(X \leq 12)$ For 0.1316	Notation $P(X = 13)$ scores M0. If they have the correct $P(X \geq 13)$ then give M1 and ignore any further incorrect notation. Or for 1 – 0.8684 indep of previous mark
			$0.1316 > 0.05$	M1* dep	For comparison with 5%	
			So not significant	A1*		Allow 'accept H_0' or 'reject H_1'
			There is insufficient evidence to suggest that people can make a correct identification.	E1* dep	NB Point probabilities score zero.	Must include 'insufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark. Must be in context to gain E1 mark. Do not allow 'sufficient evidence to suggest proportion making correct identification is 0.5' or similar

Question			Answer	Marks	Guidance	
			ALTERNATIVE METHOD – follow method above unless some mention of CR seen		Must see some reference to CR to gain any marks	
			Critical region method UPPER TAIL $P(X \geq 14) = 1 - P(X \leq 13) = 1 - 0.9423 = 0.0577 > 5\%$ $P(X \geq 15) = 1 - P(X \leq 14) = 1 - 0.9793 = 0.0207 < 5\%$	B1 M1*	For either probability For a correct comparison with 5%	Do not insist on correct notation as candidates have to work out two probabilities for full marks. Allow comparison in form of statement 'critical region at 5% level is …'
			So critical region is {15,16,17,18,19,20}	M1* dep	cao dep on the two correct probabilities	No marks if CR not justified Condone {15, … 20}, $X \geq 15$, oe but not $P(X \geq 15,)$ etc
			13 not in CR so not significant	A1*	Must include '13 not in CR'	Allow 'accept H_0' or 'reject H_1'
			There is insufficient evidence to indicate that people can make a correct identification.	E1* dep on A1	Ignore any work on lower critical region	NB If CR found correctly, **then P(X=13) subsequently found,** but cand says '13 not in CR' then allow up to all five marks. If do not say '13 not in CR' allow no marks
				[5]		

Question			Answer	Marks	Guidance	
6	(i)		Median = 3.32 kg Q1 (= 6.5th value) = 2.83 Q3 (= 19.5th value) = 3.71 Inter-quartile range = 3.71 – 2.83 = 0.88	B1 B1 B1 **[3]**	 For Q1 or Q3 For IQR dep on both quartiles correct	For Q1 allow 2.82 to 2.84 For Q3 allow 3.70 to 3.72 If no quartiles given allow B0B1 for IQR in range 0.86 to 0.90
	(ii)			G1 G1 G1	For reasonably linear scale shown. For boxes in approximately correct positions, with median just to right of centre For whiskers in approximately correct positions in proportion to the box FT their median and quartiles if sensible – guidance above is only for correct values	Dep on attempt at box and whisker plot with at least a box and one whisker. Condone lack of label. Do not award unless RH whisker significantly shorter than LH whisker Allow LH whisker going to 2.5 and outlier marked at 1.39
				[3]		
6	(iii)		Lower limit 2.83 – (1.5 × 0.88) = 1.51 Upper limit 3.71 + (1.5 × 0.88) = 5.03 Exactly one baby weighs less than 1.51 kg and none weigh over 5.03 kg so there is exactly one outlier.	B1 B1 E1*	For 1.51 FT For 5.03 FT Dep on their 1.51 and 5.03	Any use of <u>median</u> ± 1.5 × IQR scores B0 B0 E0 No marks for ± 2 or 3 × IQR In this part FT their values from (i)or (ii) if sensibly obtained but not from location ie 6.5, 19.5 Do not penalise over-specification as not the final answer Do not allow unless FT leads to upper limit above 4.34 and lower limit between 1.39 and 2.50

Question			Answer	Marks	Guidance	
			'Nothing to suggest that this baby is not a genuine data value so she should not be excluded' or 'This baby is premature and therefore should be excluded'.	E1* Dep **[4]**	Any sensible comment in context	For use of mean ± 2sd allow B1 For 3.27 + 2 × 0.62= 4.51 B1 For 3.27 - 2 × 0.62= 2.03 Then E1E1 as per scheme
6	**(iv)**		Median = 3.5 kg Q1 = 50th value = 3.12 Q3 = 150th value = 3.84 Inter-quartile range = 3.84 – 3.12 = 0.72	B1 B1 B1 **[3]**	For Q1 or Q3 For IQR FT their quartiles	For Q1 allow 3.11 to 3.13 For Q3 allow 3.83 to 3.85 Dep on both quartiles correct If no quartiles given allow B0B1 for IQR in range 0.70 to 0.74
6	**(v)**		Female babies have lower weight than male babies on the whole Female babies have higher weight variation than male babies	E1 FT E1 FT **[2]**	Allow 'on average' or similar in place of 'on the whole' Allow 'more spread' or similar but not 'higher range' Condone less consistent	Do not allow lower median Do not allow higher IQR, but SC1 for both lower median and higher IQR, making clear which is which
6	**(vi)**		Male babies must weigh more than 4.34 kg			
			Approx 10 male babies weigh more than this.	M1*	For 10 or 9 or 8	Or 200 – 190, 200 –191 or 200 –192
			Probability = $\frac{10}{200}\times\frac{9}{199}=\frac{90}{39800}=\frac{9}{3980}=0.00226$ or $\frac{9}{200}\times\frac{8}{199}=\frac{72}{39800}=0.00181$ or $\frac{8}{200}\times\frac{7}{199}=\frac{56}{39800}=\frac{7}{4975}=0.00141$	M1* dep A1	For first fraction multiplied by any other different fraction (Not a binomial probability) CAO Allow their answer to min of 2 sf	Allow any of these answers For spurious factors, eg 2 × correct answer allow M1M1A0 SC1 for $n/200 \times (n-1)/199$
				[3]		

Question			Answer	Marks	Guidance	
7	(i)			G1 G1 G1 G1 **[4]**	For first set of branches For second set of branches (indep) For third set of branches (indep) For labels	All probabilities correct All probabilities correct All probabilities correct All correct labels for 'Hit' and 'Miss', 'H' and 'M' etc. Condone omission of First, Second, Third. Do not allow misreads here as all FT
7	(ii)	*A*	P(Hits with at least one) = 1 – P(misses with all) = 1 – (0.9 × 0.95 × 0.95) = 1 – 0.81225 = 0.18775 ALTERNATIVE METHOD only if there is an attempt to add 7 probabilities At least three correct triple products Attempt to add 7 triple products FURTHER ALTERNATIVE METHOD 0.1 + 0.9 × 0.05 Above probability + 0.9 × 0.95 × 0.05	M1* M1* dep A1 M1 M1 A1 M1 M1 A1 **[3]**	For 0.9 × 0.95 × 0.95 For 1 – ans CAO CAO CAO	FT their tree for both M marks, provided three terms 0.188 or better. Condone 0.1877 Allow 751/4000 (not necessarily correct triple products)

Question			Answer	Marks	Guidance	
7	(ii)	*B*	P(Hits with exactly one) = (0.1 × 0.8 × 0.95) + (0.9 × 0.05 × 0.8) + (0.9 × 0.95 × 0.05)	M1 M1	For two correct products For all three correct products	FT their tree for all three M marks, provided three terms
			$= 0.076 + 0.036 + 0.04275 = \frac{19}{250} + \frac{9}{250} + \frac{171}{4000}$	M1	For sum of all three correct products	
			$= \frac{619}{4000} = 0.15475$	A1 **[4]**	CAO	Allow 0.155 or better
7	(iii)		P(Hits with exactly one given hits with at least one) $= \frac{\text{P(Hits with exactly one and hits with at least one)}}{\text{P(Hits with at least one)}}$			If answer to (*B*) > than answer to (*A*) then max M1M0A0
			$= \frac{0.15475}{0.18775}$	M1 M1	For numerator FT For denominator FT	Both must be part of a fraction
			= 0.8242	A1 **[3]**	CAO	Allow 0.824 or better or 619/751
7	(iv)		P(Hits three times overall) = (0.1 × 0.2 × 0.2) + (0.9 × 0.95 × 0.95 × 0.05 × 0.2 × 0.2)	M1	For 0.1 × 0.2 × 0.2 or 0.004 or 1/250	FT their tree for all three M marks
				M1	For 0.9 × 0.95 × 0.95 × 0.05 × 0.2 × 0.2	provided three terms in first product and six in second product. Last three probs must be 0.05 × 0.2 × 0.2 unless they extend their tree
			= 0.004 + 0.0016245	M1* Dep on both prev M1's	For sum of both	With no extras
			= 0.0056245	A1 **[4]**	CAO	Allow 0.00562 or 0.00563 or 0.0056

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.

PLEASE HIGHLIGHT ANY OVER-SPECIFICATION

Please note that there are no G or E marks in scoris, so use B instead

NB PLEASE ANNOTATE EVERY ADDITIONAL ANSWER SHEET EVEN IF FULL MARKS AWARDED OR THE PAGE IS BLANK

Additional notes re Q5 part iii

Comparison with 95% method
If 95% seen anywhere then
M1 for P($X \leq 12$)
B1 for 0.8684
M1* for comparison with 95% dep on second B1
A1* for not significant oe
E1*

Comparison with 95% CR method
If 95% seen anywhere then
B1 for 0.9423 or 0.9793
M1 for correct comparison with 95%
M1dep for correct CR provided both probs correct
then follow mark scheme for CR method

Smallest critical region method:
Smallest critical region that 13 could fall into is {13, 14, 15, 16, 17, 18, 19, 20} **gets B1 and has size 0.1316 gets B1, This is > 5% gets M1*, A1*, E1* as per scheme**
NB These marks only awarded if 13 used, not other values.

Use of *k* method with no probabilities quoted:
This gets zero marks.

Use of *k* method with one probability quoted:
Mark as per scheme

Line diagram method and Bar chart method
No marks unless correct probabilities shown on diagram, then mark as per scheme..