<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th colspan="2">Guidance</th></tr>
<tr><td>1</td><td>(i)</td><td></td><td>Positive</td><td>B1
[1]</td><td>CAO</td><td></td></tr>
<tr><td>1</td><td>(ii)</td><td></td><td>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</td><td>B1
B2

[3]</td><td>
Allow B1 for RMSD = 1.297 or var =1.753
or MSD = 1.683</td><td>
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)</td></tr>
<tr><td>1</td><td>(iii)</td><td></td><td>$\overline{x} - 2s = 5.064 - 2\times1.324 = 2.416$

$\overline{x} + 2s = 5.064 + 2\times1.324 = 7.712$

So there is an outlier.</td><td>B1FT

M1

A1FT
E1

[4]</td><td>FT their mean and sd

for $\overline{x} + 2s$ 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</td><td>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</td></tr>
<tr><td>2</td><td>(i)</td><td></td><td><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>
$3k + 8k + 15k + 24k = 1$

$k = 0.02$</td><td>B1

M1

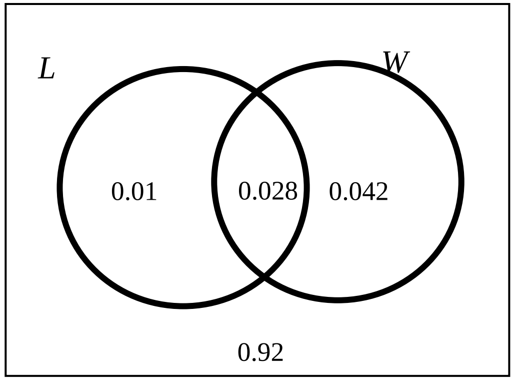
A1

[3]</td><td>For correct table (ito k or correct probabilities 0.06, 0.16, 0.30, 0.48)

or $k = 1/50$ (with or without working)</td><td>

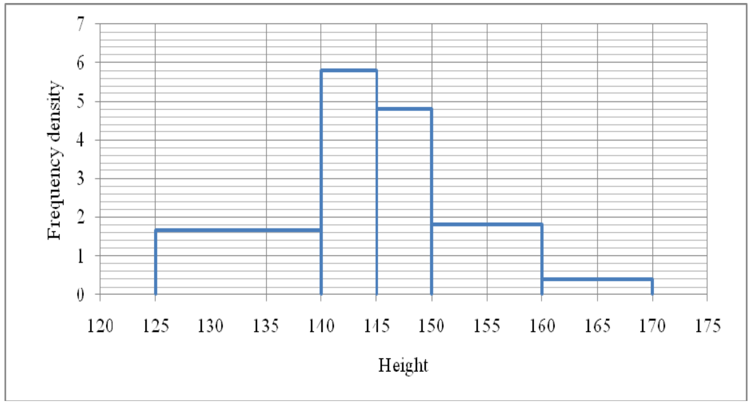
For their four multiples of k added and =1.
Allow M1A1 even if done in part (ii) – link part (ii) to part (i)</td></tr>
</table>

Question			Answer	Marks	Guidance	
2	(ii)		$E(X) = (2\times 0.06)+(3\times 0.16)+(4\times 0.30)+(5\times 0.48) = 4.2$	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 $\neq$ 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. $E(X) = 210k$, Var $(X) = 924k - (210k)^2$ gets M1A0M1M1A0.
			$E(X^2) = (4\times 0.06)+(9\times 0.16)+(16\times 0.30)+(25\times 0.48) = 18.48$	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)		$P(L\cap W) = P(L\mid W)\times P(W) = 0.4\times 0.07 = 0.028$	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 × 0.1212…)
				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)**		$4 + \frac{1}{2}$ 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)	(table 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

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<tr><td></td><td></td><td></td><td></td><td>[5]</td><td></td><td>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)</td></tr>
<tr><td>6</td><td>(iv)</td><td></td><td>4 boys
0.6 × 15

= 9 girls
So 5 more girls</td><td>
M1

A1
A1
[3]</td><td>
For 0.6 × 15

For 9 girls
cao</td><td>
Or 45 × 0.2 = 9 (number of squares and 0.2 per square)</td></tr>
<tr><td>6</td><td>(v)</td><td></td><td>Frequencies and midpoints for girls are
Height: 132.5, 142.5, 147.5, 155, 167.5
Frequency: 18, 23, 31, 19, 9

So mean = $\frac{(132.5\times18)+(142.5\times23)+(147.5\times31)+(155\times19)+(167.5\times9)}{100}$

$=\frac{(2385)+(3277.5)+(4572.5)+(2945)+(1507.5)}{100}$
= 146.9
(Exact answer 146.875)</td><td>B1

B1

M1
M1* Dep on M1

A1

[5]</td><td>For at least three frequencies correct

At least three midpoints correct

For attempt at $\sum xf$
For division by 100

Cao

NB Watch for over-specification</td><td>

No further marks if not using midpoints

For sight of at least 3 xf pairs

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</td></tr>
</table>

Question			Answer	Marks	Guidance	
7	(i)	(*A*)	$X \sim \text{B}(10, 0.35)$ P(5 accessing internet) = $\binom{10}{5} \times 0.35^5 \times 0.65^5$ = 0.1536 **OR** from tables = 0.9051 – 0.7515 = 0.1536	M1 M1 A1 **OR** M2 A1 **[3]**	or $0.35^5 \times 0.65^5$ For $\binom{10}{5} \times p^5 \times q^5$ cao For 0.9051 – 0.7515 cao	With p + q = 1 Also for 252 × 0.0006094 Allow 0.15 or better NB 0.153 gets A0 See tables at the website http://www.mei.org.uk/files/pdf/formula_book_mf2.pdf
7	(i)	(*B*)	$\text{P}(X \geq 5) = 1 - \text{P}(X \leq 4)$ =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*)	$\text{E}(X) = np = 10 \times 0.35$ = 3.5	M1 A1 **[2]**	For 10 × 0.35 cao	If any indication of rounding to 3 or 4 allow M1A0

Question			Answer	Marks	Guidance	
7	(ii)		Let X ~ 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.	A1*		Allow 'accept H_0' or 'reject H_1'
			Conclude that there is not enough evidence to indicate that the probability is different. (Must state 'probability', not just 'p')	E1* dep on A1		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($X \le 9$)

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 ≥ 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.