1 (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: $\frac{1}{4} \ge \frac{1}{3} \ge \frac{1}{2}$ NOTE: <b>ANSWER GIVEN</b>	E1 E1 B1 for $\frac{1}{4} \ge \frac{1}{3}$ B1 for $\ge \frac{1}{2}$	2
(iii)	E(X) = 1 x $\frac{1}{3}$ + 2 x $\frac{1}{4}$ + 4 x $\frac{1}{24}$ = 1	M1 For $\sum xp$ (at least 2 non- zero terms correct) A1 CAO	
	E(X <sup>2</sup> ) = 1 x $\frac{1}{3}$ + 4 x $\frac{1}{4}$ + 16 x $\frac{1}{24}$ = 2 So Var(X) = 2 - 1 <sup>2</sup> = 1	M1 for $\sum x^2 p$ (at least 2 non- zero terms correct) M1 <i>dep</i> for – their E(X) <sup>2</sup> A1 FT their E(X) provided Var(X) > 0	5
		TOTAL	8

2	The company could increase the mean weight.	B1 CAO	
(i)	The company could decrease the standard	B1	
	deviation.		
			2
	Sample mean = $11409/25 = 456.36$	B1	
( <b>ii</b> )			
	a 11409 <sup>2</sup>		
	$S_{xx} = 5206937 - \frac{11409^2}{25} = 325.76$	M1 for $S_{xx}$	
	325.76		
	Sample s.d = $\sqrt{\frac{325.76}{24}} = 3.68$	A1	
	V 27		3
		TOTAL	5
		TOTAL	

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
	Var $(X) = (2+24+108+320)\frac{1}{40} - 3.2$	M1 M1 dep	Sum of r <sup>2</sup> p -3.25
	= 11.35 - 10.5625		
	= 0.7875	A1 cao	
(iii)	Expected number of weeks = $\frac{6}{40} \times 45$ = 6.75 weeks	M1 A1	Use of np

4 (i)	Mean = 83.95/8 = 10.49	B1	
	Variance = $\frac{881.2119 - \frac{83.95^2}{8}}{7}$ = 0.03737	M1	
	Standard deviation $= 0.193$	A1	
(ii)	2 standard deviations below mean		
	= 10.49 - 2(0.193)	M1	Follow through if divisor n has been
	= 10.104		used above.
	but 10.04 < 10.104		
	so 10.04 is an outlier.	A1	
(iii)	This time is much faster than the others. This may be the result of wind assistance, faulty timing, false start	E1	Appreciating need for investigation
	and should be discarded. Opposite conclusion such as this could be a genuinely fast time, can also receive full credit.	E1	Comment in context

5 (i)	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	B1 B1 M1	1 value correct all 3 correct sum of 1
(ii)	E(X) = 110k = 2.2	M1 A1	sum of rp cao
(iii)	P(X > 2.2) = 22k = 0.44	B1	

Question			Answer		Marks	G	uidance
6 (i)	Weight $30 \le w < 50$ $50 \le w < 60$ $60 \le w < 70$ $70 \le w < 80$ $80 \le w < 90$	Frequency           11           10           18           14           7	Group Width 20 10 10 10 10 10	Frequency density           0.55           1           1.8           1.4           0.7	M1	For fd's - at least 3 correct Accept any suitable unit for fd such as eg freq per 10g.	M1 can be also be gained from freq per $10 - 5.5$ , 10, 18, 14, 7 (at least 3 correct) or similar. If fd not explicitly given, M1 A1 can be gained from all heights correct (within half a square) on histogram (and M1A0 if at least 3 correct)
	2 1.8 1.6 1.6 1.4 1.2 1.2 1.0 1.2 0.8 0.6 0.4 0.2 0 20 3	30 40 50	0 60 70 Weight	80 90 100	G1	linear scales on both axes and labels Vertical scale starting from zero (not broken - but can get final mark for heights if broken)	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) Ignore horizontal label Can also be gained from an accurate key
					G1	width of bars	G0 if correct label but not fd's. Must be drawn at 30, 50 etc NOT 29.5 or 30.5 etc NO GAPS ALLOWED Must have linear scale. No inequality labels on their own such as $30 \le W \le 50$ , $50 \le W \le 60$ etc but allow if 30, $50$ , $60$ etc occur at the correct boundary position. See additional notes. Allow this mark even if not using fd's

Qu	estion	Answer	Marks	Guidance	
			G1	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 fds
					If fds not given and at least 3 heights correct then max M1A0G1G1G0
			[5]		Allow restart with correct heights if given fd wrong (for last three marks only)

Question	Answer	Marks	G	uidance
6 (ii)	$\frac{\text{Mean} = \frac{(40 \times 11) + (55 \times 10) + (65 \times 18) + (75 \times 14) + (85 \times 7)}{60} = \frac{3805}{60}$	M1	For midpoints Products are 440, 550, 1170, 1050, 595	For midpoints (at least 3 correct) No marks for mean or sd unless using midpoints
	$= 63.4  (or \ 63.42)$	A1	CAO (exact answer 63.41666)	Answer must NOT be left as improper fraction as this is an estimate Accept correct answers for mean and sd from calculator even if eg wrong Sxx given
	$\Sigma x^{2} f = \frac{(40^{2} \times 11) + (55^{2} \times 10) + (65^{2} \times 18) + (75^{2} \times 14) + (85^{2} \times 7)}{= 253225}$			
	$S_{xx} = 253225 - \frac{3805^2}{60} = 11924.6$	M1	For attempt at $S_{xx}$ Should include sum of at least 3 correct multiples $fx^2$ $-\Sigma x^2/n$	Allow M1 for anything which rounds to 11900
	$s = \sqrt{\frac{11924.6}{59}} = \sqrt{202.11} = 14.2$	A1	At least 1dp required Use of mean 63.4 leading to answer of 14.29199 with $S_{xx} = 12051.4$ gets full credit. 63.42 leads to 14.2014 Do not FT their incorrect mean	Allow SC1 for RMSD 14.1 (14.0976) from calculator. Only penalise once in part (ii) for over specification, even if mean and standard deviation both over specified. If using $(x - \bar{x})^2$ method, B2 if
		[4]	(exact answer14.2166)	14.2 or better (14.3 if use of 63.4), otherwise B0

	Questi	ion	Answer	Marks	G	uidance
6	(iii)		$\overline{x} - 2s = 63.4 - (2 \times 14.2) = 35$	M1	For either No marks in (iii) unless using $\overline{x} + 2s$ or $x - 2s$	Only follow through numerical values, not variables such as <i>s</i> , so if a candidate does not find <i>s</i> but then writes here 'limit is $63.4 + 2 \times$ standard deviation', do NOT award M1
			$\overline{x} + 2s = 63.4 + (2 \times 14.2) = 91.8$	A1	For both (FT)	Do not penalise for over- specification
			So there are probably some outliers at the lower end, but none at the upper end	E1	Must include an element of doubt and must mention both ends	Must have correct limits to get this mark
				[3]		
6	(iv)		Mean = $\frac{3624.5}{50}$ = 72.5g (or exact answer 72.49g)	B1	CAO Ignore units	
			$S_{xx} = 265416 - \frac{3624.5^2}{50} = 2676$	M1	For S <sub>xx</sub>	M1 for 265416 - 50 × their mean <sup>2</sup> BUT NOTE M0 if their $S_{xx} < 0$
			$s = \sqrt{\frac{2676}{49}} = \sqrt{54.61} = 7.39g$	A1	CAO ignore units Allow 7.4 but NOT 7.3 (unless RMSD with working)	For $s^2$ of 54.6 (or better) allow M1A0 with or without working. For RMSD of 7.3 (or better) allow M1A0 provided working seen For RMSD <sup>2</sup> of 53.5 (or better) allow M1A0 provided working seen
				[3]		

QuestionAnswerMarks		G	uidance		
6	( <b>v</b> )	Variety A have lower average than Variety B oe	E1	FT their means Do not condone lower central tendency or lower mean	Allow 'on the whole' or similar in place of 'average'.
		Variety A have higher variation than Variety B oe	E1	FT their sd	Allow 'more spread' or similar but not 'higher range' or 'higher variance' Condone less consistent.
			[2]		

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

(ii)	$\begin{aligned} & P(Two \ \pounds 10 \ or \ two \ \pounds 100) \\ &= \frac{50}{10000} \times \frac{49}{9999} + \frac{20}{10000} \times \frac{19}{9999} \\ &= 0.0000245 + 0.0000038 = (0.00002450245 + 0.00000380038) \\ &= 0.000028(3) \ \text{o.e.} = (0.00002830283) \\ &\underline{After \ M0, \ M0} \ then \ \frac{50}{10000} \times \frac{50}{10000} + \frac{20}{10000} \times \frac{20}{10000} \ o.e. \\ & Scores \ SC1 \ (ignore \ final \ answer \ but \ SC1 \ may \ be \ \mathsf{implied \ by} \\ & sight \ of \ 2.9 \times 10^{-5} \ o.e.) \\ & Similarly, \ \frac{50}{10000} \times \frac{49}{10000} + \frac{20}{10000} \times \frac{19}{10000} \ scores \ SC1 \end{aligned}$	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) <u>CARE</u> answer is also $2.83 \times 10^{-5}$	3
		TOTAL	7