Mark Scheme

Q1.

Question Number	Scheme		Marks
	$N(0.2n, 0.16n)$	B1: Mean $= 0.2n$ and Var $= 0.16n$ oe this may be awarded if they appear in the standardisation as $0.2n$ and either $0.16n$ or $\sqrt{0.16n}$	B1
	$P\left(Z > \frac{55.5-0.2n}{\sqrt{0.16n}}\right) = 0.0401$	M1: Using a continuity correction either 55.5 or 54.5	M1
	$\frac{55.5-0.2n}{\sqrt{0.16n}} = 1.75$	B1: Using a z = awrt $\pm$ 1.75 M1: Standardising using either 55.5, 54.5 or 55 and equal to a z value. Follow through their mean and variance. If they have not given the mean and Var earlier then they must be correct A1: A correct equation. May be awarded for $\frac{55.5-0.2n}{\sqrt{0.16n}} = 1.75$ Condone use of an inequality sign rather than an equals sign	B1M1A1
	$0.2n + 0.7\sqrt{n} - 55.5 = 0$	M1d: This is dependent on the previous method mark being awarded. Using either the quadratic formula or completing the square or factorising or any correct method to solve **their 3 term** equation. If they write the formula down then allow a slip. If no formula written down then it must be correct for their equation. May be implied by correct answer or $\sqrt{n} = 15$ or 342.25 **NB** you may award this mark if they use 54.5 for awrt 14.9, -18.4, 221 or 337 55 for awrt -18.4, 14.9,223 or -117 If the answer is not one of these then the method for solving their 3 term equation must be seen.	M1d
	$\sqrt{n} = 15$	A1: Allow 15 or -18.5 do not need to see n or $\sqrt{n}$. Condone $n = 15$ or $n = -18.5$	A1
	$n = 225$	A1 : cao 225 do not need to see n or $\sqrt{n}$	A1 (8)

	Alternative method for last 3 marks $(0.2n-55.5)^2=(-0.7\sqrt{n})^2$ $0.04n^2-22.69n+3080.25=0$ $n=225$ or 1369/4 $n=225$	M1 solving 3 term quadratic in n as above A1 either 225 or 1369/4 or 342.25 A1must select 225	**Total 8**

Q2.

Question Number	Scheme		Marks
(a)	$z=\frac{53-50}{2}$	Attempt to standardise	M1
	$P(X>53)=1-P(Z<1.5)$	1-probability required can be implied	B1
	=1-0.9332 =0.0668		A1 (3)
(b)	$P(X\le x_0)=0.01$		M1
	$\frac{x_0-50}{2}=-2.3263$		M1 B1
	$x_0=45.3474$	awrt 45.3 or 45.4	M1 A1 (5)
(c)	P(2 weigh more than 53kg and 1 less) $=3\times0.0668^2(1-0.0668)$		B1 M1 A1ft
	$=0.012492487..$	awrt 0.012	A1 (4)
			(12 marks)

Q3.

Question Number	Scheme	Marks
(a)	n is large and p close to 0.5	B1B1 (2)
(b)	There would be no pea seeds left	B1 (1)
(c)	H_0: $p = 0.55$ H_1 : $p \neq 0.55$	B1 (1)
(d)	X~N(121, 54.45)	B1
	$P(X \geq 134.5) = P\left(Z \geq \frac{134.5-121}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$	M1M1A1
	$= P(Z \geq 1.8295..)$	
	$= 1 - 0.9664$	
	$= 0.0336/0.0337$ $\quad x = 135.96$	A1
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** **55**% of its pea **seeds germinate**	A1cso (7)
	Alternative	
	X~N(99, 54.45)	B1
	$P(X \leq 85) = P\left(Z \leq \frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96$	M1 M1 A1
	$= P(Z \geq 1.8295..)$	
	$= 1 - 0.9664$	
	$= 0.0336/0.0337$ $\quad x = 107.5$	
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** **55**% of its pea **seeds germinate**	A1cso [11]
	Notes	
(a)	B1 accept $n > 50$ (or any number bigger than 50) B1 p close to 0.5 NB Do not accept $np > 5$, $nq > 5$.	
(b)	Must have the idea of no peas left. They must mention either **pea** or **seeds**.	
(c)	B1 both hypotheses correct. Must use p or π and 0.55 oe. Accept the hypotheses in part (d).	
(d)	B1 correct mean and Var, may be seen in the standardiation formula as 121 and $\sqrt{54.45}$ or	

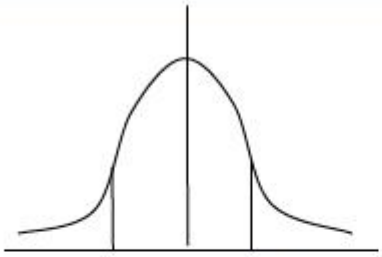
	7.38 to 2dp or implied by a correct answer M1 for attempting a continuity correction (Method 1:135/85 ± 0.5 / Method 2:x ± 0.5) M1 for standardising using their mean and their standard deviation and using either Method 1 [134.5, 135, 135.5, 85, 85.5 or 84.5 accept ± z.] Method 2 [(x ± 0.5) and equal to a ± z value] A1 correct z value awrt ± 1.83 **or** $\pm\frac{134.5-121}{\sqrt{54.45}}$ $\left(\frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}}=1.96$ $\left(\pm\frac{x+0.5-99}{\sqrt{54.45}}=1.96\right)$ or(allow 1.6449 if 1 tail test in (c)) A1 awrt 0.0336/0.0337 **or** awrt 136 (allow 126 if one tail test in (c)) or a comparison of awrt1.83 with 1.96 (1.6449) M1 A correct statement. Accept H_0, oe if a 2-tailed test in (c), reject H_0, oe if a 1-tailed test in (c). Allow for a correct contextual statement. Do not allow contradictions of non-contextual statements. A1 A correct contextual statement to include words in bold/underlined for a 2-tailed test. This is not a follow through mark. NB if finding P(X =135) they can get B1 M1 M1 A0 A0 M0 A0

Q4.

Question	Scheme	Marks	AOs
(a)	$\frac{24.63-25}{'\sigma'}=-1.0364$	M1	3.1b
	$[\sigma =]0.357$ (must come from compatible signs)	A1	1.1b
	$P(D>k)=0.4$ or $P(D<k)=0.6$	B1	1.1b
	$\frac{k-25}{'0.357'}=0.2533$	M1	3.4
	$k=$ awrt **25.09**	A1	1.1b
		(5)	
(b)	$[Y\sim B(200, 0.45)\rightarrow]\ W\sim N(90, 49.5)$	B1	3.3
	$P(Y<100)\approx P(W<99.5)\left[=P\left(Z<\frac{99.5-90}{\sqrt{49.5}}\right)\right]$	M1	3.4
	$=0.9115\ldots$ awrt **0.912**	A1	1.1b
		(3)	
(c)	$H_0:\mu=25$ $H_1:\mu<25$	B1	2.5
	$[\bar{D}\sim]N\left(25,\frac{0.16^2}{20}\right)$	M1	3.3
	$P(\bar{D}<24.94)[=P(Z<-1.677...)]=0.046766...$	A1	3.4
	$p=0.047<0.05$ or $z=-1.677\ldots<-1.6449$ or $24.94<24.94115\ldots$ or reject H_0 /in the critical region/significant	M1	1.1b
	There is sufficient evidence to support Hannah's belief.	A1	2.2b
		(5)	
			(13 marks)

Notes	
(a)	**M1:** for standardising 24.63, 25 and 'σ' (ignore label) and setting = to z where $1 < \lvert z \rvert < 2$ **A1:** [$\sigma =$] awrt 0.36. Do **not** award this mark if signs are not compatible. **B1:** for either correct probability statement (may be implied by correct answer) this mark may be scored for a correct region shown on a diagram **M1:** for a correct expression with z = awrt 0.253 (may be implied by correct answer) **A1:** awrt 25.09 (Correct answer with no incorrect working scores 5 out of 5)
(b)	**B1:** setting up normal distribution approximation of binomial N(90, 49.5) (may be implied by a correct answer) Look out for e.g. $\sigma = \frac{3\sqrt{22}}{2}$ or $\sigma =$ awrt 7.04 **M1:** attempting a probability using a continuity correction i.e. P($W < 100.5$), P($W < 99.5$) or P($W < 98.5$) condone $\leq$ (The continuity correction may be seen in a standardisation). **A1:** awrt 0.912 [Note: 0.911299… from binomial scores 0 out of 3]
(c)	**B1:** for both hypotheses in terms of μ **M1:** selecting suitable model must see N(ormal), mean 25, sd $= \frac{0.16}{\sqrt{20}}$ (o.e.) or var $= \frac{4}{3125}$ (o.e.) Condone N(25, $\frac{0.16}{\sqrt{20}}$) if $\frac{0.16}{\sqrt{20}}$ then used as s.d. **A1:** p value = awrt 0.047 or **test statistic** awrt −1.68 or **CV** awrt 24.941 (any of these values imply the M1 provided they do not come from Normal mean = 24.94) **M1:** a correct comparison (including compatible signs) **or** correct non-contextual conclusion (f.t. their p value, test statistic or critical value in the comparison) M1 may be implied by a correct contextual statement **NB** Any contradictory non contextual statements/comparisons score M0A0 e.g. '$p < 0.05$, not significant' **A1:** correct conclusion in context mentioning Hannah's belief or the mean amount/liquid in each bottle is now less than 25ml **(dep on M1A1M1)**

Q5.

Question	Scheme	Marks	AOs
(a)			
	P $(L > 50.98) = 0.025$	B1cao	3.4
	$\therefore \frac{50.98-\mu}{0.5} = 1.96$	M1	1.1b
	$\therefore \quad \mu = 50$	A1cao	1.1b
	P$(49 < L < 50.75)$	M1	3.4
	$= 0.9104\ldots$ awrt **0.910**	A1ft	1.1b
		(5)	
(b)	S = number of strips that cannot be used so $S \sim B(10, 0.090)$	M1	3.3
	$= P(S \leqslant 3) = 0.991166\ldots$ awrt 0.991	A1	1.1b
		(2)	
(c)	$H_0 : \mu = 50.1$ $H_1 : \mu > 50.1$	B1	2.5
	$\bar{X} \sim N\left(50.1, \frac{0.6^2}{15}\right)$ and $\bar{X} > 50.4$	M1	3.3
	$P(\bar{X} > 50.4) = 0.0264$	A1	3.4
	$p = 0.0264 > 0.01$ or $z = 1.936\ldots < 2.3263$ and not significant	A1	1.1b
	There is insufficient evidence that the **mean length** of strips is **greater than 50.1**	A1	2.2b
		(5)	
			(12 marks)

Notes:
(a) **1st M1:** for standardizing with μ and 0.5 and setting equal to a z value ($\|z\| > 1$) **2nd M1:** for attempting the correct probability for strips that can be used **2nd A1ft:** awrt 0.910 (allow ft of their μ)
(b) **M1:** for identifying a suitable binomial distribution **A1:** awrt 0.991 (from calculator)
(c) **B1:** hypotheses stated correctly **M1:** for selecting a correct model (stated or implied) **1st A1:** for use of the correct model to find p = awrt 0.0264 (allow z = awrt 1.94) **2nd A1:** for a correct calculation, comparison and correct statement **3rd A1:** for a correct conclusion in context mentioning "mean length" and 50.1

Q6.

Qu	Scheme	Marks	AO
(a)	[Let N = height from region A; P($N > 180$) =] 0.24937… awrt **0.249**	B1 (1)	1.1b
(b)	$H_0 : \mu = 175.4$ $H_1 : \mu \neq 175.4$	B1	2.5
	[S = height from region B] $\bar{S} \sim N\left(175.4, \frac{6.8^2}{52}\right)$ Allow σ^2 = awrt 0.889	M1	3.3
	[P($\bar{S} > 177.2$)] = 0.02814…	A1	3.4
	[0.028… > 0.025, Not sig, do not reject H_0] Insufficient evidence to support student's claim	A1 (4)	2.2b
(c)	[p-value = $2 \times 0.02814...$ =] 0.05628… in range **0.056~0.06** or **5.6(%)~6(%)**	B1ft (1)	1.2
		(6 marks)	

	Notes
(a)	B1 for awrt 0.249
(b)	B1 for both hypotheses correct in terms of μ **(See below for one-tail test)**
	M1 for selecting the correct model, may be implied by standardisation using correct values or may be implied by a correct value in 1st A1 e.g.(Prob =) 0.028 or awrt 0.972, (Z =) 1.9(08..) (CV=) 177.25 Condone use of S (or any other letter) instead of $\bar{S}$ Condone use of $\bar{S} \sim N\left(177.2, \frac{6.8^2}{52}\right)$ but **this will lose 2nd A mark**
	1st A1 for probability of awrt 0.028 (allow 0.03 if P($\bar{S}$ > 177.2) is seen) Condone 1 – 0.02814 … = 0.9718…(awrt 0..972) **only if clearly compared with 0.975**
ALT	Allow Z = 1.9(088…) and comparison with 1.96 (or better: calc gives 1.95996…)
	or CR of $\left[\bar{S}\right]$… 177.248…(awrt 177.25) Allow $\left[\bar{S}\right]$ >=177.248…(awrt 177.25) Implied by diagram or correct interpretation of inequality with their CV (Ignore any attempt at a lower CR for $\bar{S}$)
	2nd A1 (dep on 1st A1 and use of correct model. Use of N(177.2, …) scores A0) for a conclusion using context: e.g. does not support student's claim or e.g. insufficient evidence of a difference in heights Do not allow 2nd A mark for contradictory statements e.g. "significant" so "no support for claim"
(c)	B1ft for answer in range 0.056--0.06 or 5.6%--6% (Ranges are inclusive, condone missing %) (can ft their probability, provided < 0.5, from part (b) but not 0.025 leading to 5%)
NB	**One-tail test [Max of 3/5 for (b) and (c)]** In (b) B0 (hypotheses) M1(model as above) 1st A1[for probability or Z compared with 1.6449 or CR $\left[\bar{S}\right]$… or > 176.95… (awrt 177)] 2nd A1 for conclusion in context that supports claim **or** "heights of men from B is different from/greater than from A" In (c) B0

Q7.

Question	Scheme	Marks
(a)	$[z=]\pm\left(\frac{150-162}{7.5}\right)$	M1
	$[z=]-1.6$	A1
	$[P(F>150)=P(Z>-1.6)=]=0.9452(0071\ldots)$ **awrt 0.945**	A1 (3)
(b)	$z=\pm 0.2533$ (or better seen)	B1
	$(\pm)\frac{s-162}{7.5}=0.2533(47\ldots)$	M1
	$s=163.9$ **awrt 164**	A1 (3)
(c)	$z=\pm 1.2816$ (or better seen)	B1
	$\frac{162-\mu}{9}=-1.2815515\ldots$	M1 A1
	$\mu=173.533\ldots$ **awrt 174**	A1 (4)
		[10]

	Notes
(a)	M1 for attempting to standardise with 150, 162 and 7.5. Accept $\pm$ Allow use of symmetry and therefore 174 instead of 150 1st A1 for -1.6 seen. Allow 1.6 seen if 174 used or awrt 0.945 is seen. Sight of 0.945(2) is A1. 2nd A1 for awrt 0.945 Do not apply ISW, if 0.9452 is followed by 1 – 0.9452 then award A0 Correct answer only 3/3
(b)	B1 for $(z=)\pm 0.2533$ (or better) seen. Giving $z=\pm 0.25$ or ± 0.253 scores B0 here but may get M1A1 M1 for standardising with s (o.e.), 162 and 7.5, allow $\pm$, and setting equal to a z value Only allow $0.24\leq z\leq 0.26$ Condone e.g. 160 for 162 etc A1 for awrt 164 (Correct answer only scores B0M1A1)
(c)	B1 for $(z=)\pm 1.2816$ (or better) seen. Allow awrt ± 1.28 if B0 scored in (b) for $z=$ awrt ± 0.25 M1 for attempting to standardise with 162, 9 and μ, and setting equal to a z value where $1.26<\lvert z\rvert<1.31$. Allow $\pm$ here so signs don't have to be compatible. 1st A1 for a correct equation with compatible signs and $1.26<\lvert z\rvert<1.31$ 2nd A1 for awrt 174 (Correct answer only scores B0M1A1A1). **Dependent on 1st A1**
NB	An equation $\frac{162-\mu}{9}=1.2816$ leading to an answer of $\mu=174$ is A0A0 unless there is clear correct working such as: $\frac{162-x}{9}=1.2816\Rightarrow x=\ldots\therefore\mu=162+(162-x)=174$ then award A1A1 A common error is: $\frac{162-\mu}{9}=1.2816$ followed by $\mu=162+9\times 1.2816$ = awrt 174 It gets A0A0

Q8.

Question	Scheme	Marks
(a)	$[P(M<145)=]\ P\left(Z<\frac{145-150}{10}\right)$	M1
	$=P(Z<-0.5)$ or $P(Z>0.5)$	A1
	= awrt **0.309**	A1 (3)
(b)	$[P(B>115)=0.15\Rightarrow]\ \frac{115-100}{d}=1.0364$ (Calc gives 1.036433...)	M1B1A1
	$d=14.5$ (Calc gives 14.4727...)	A1 (4)
(c)	$[P(X>\mu+15\mid X>\mu-15)=]\ \frac{P(X>\mu+15)}{P(X>\mu-15)}$	M1
	$=\frac{0.35}{1-0.35}$	A1
	$=\frac{7}{13}$ or **awrt 0.538**	A1 (3)
		[10]

	Notes
	Condone poor use of notation if a correct line appears later.
(a)	M1 for standardising with 145, 150 and 10. Allow $\pm$ and use of symmetry so 155 instead of 145
	1st A1 for $P(Z<-0.5)$ or $P(Z>0.5)$ i.e. a z value of ± 0.5 and a correct region indicated
	2nd A1 for awrt 0.309 Answer only is 3/3
(b)	M1 for $\pm\frac{115-100}{d}=z$ where $\lvert z\rvert>1$ Condone MR of $\mu=150$ instead of 100 for M1B1only
	B1 for a standardised expression $=\pm 1.0364$ (do not allow for use of $1-1.0364$)
	1st A1 for $z=$ awrt 1.04 and compatible signs i.e. a correct equation with $z=$ awrt 1.04
	2nd A1 for awrt 14.5 (allow awrt 14.4 if $z=$ awrt 1.04 is seen)
Calc	Answer only of awrt 14.473 scores M1B1A1A1
	Answer only of awrt 14.48 scores M1B0A1A1
(c)	M1 for a correct ratio expression need $P(X>\mu+15)$ on numerator. Allow use of a value for μ May be implied by next line.
	NB $\frac{0.35\times0.65}{0.65}=\frac{0.2275}{0.65}$ is M0
	1st A1 for a correct ratio of probabilities
	2nd A1 for awrt 0.538 or $\frac{7}{13}$ (o.e.). Allow 0.5385 provided 2nd A1 is scored.

Q9.

Qu	Scheme	Marks	AOs
(a)	$\left[\mathrm{P}(L<7.902)=0.025\Rightarrow\right]\dfrac{7.902-8}{x}=-1.96$ oe	M1	3.4
	$[x=]0.05$*	A1cso*	1.1b
	SC B1(mark as M0A1) for $\dfrac{7.902-8}{0.05}=-1.96\Rightarrow 0.024998$		
		(2)	
(b)	$\mathrm{P}(7.94\leqslant L\leqslant 8.09)=0.8490\ldots$ **awrt 0.849**	B1	1.1b
		(1)	
(c)	$[\mathrm{P}(L<7.94)=]$ 0.115069... (awrt 0.115) **or** $[\mathrm{P}(L>8.09)=]$ 0.03593... (awrt 0.036)	B1	1.1b
	$[\mathrm{P}(L<7.94)=]$ 0.115069... (awrt 0.115) **&** $[\mathrm{P}(L>8.09)=]$ 0.03593... (awrt 0.036)	B1	1.1b
	Expected income per 500 rods = $\sum(\text{Income}\times\text{probability}\times 500)$ $(500\times\text{"0.849"}\times 0.5)+(500\times\text{"0.1150..."}\times 0.05)+(500\times\text{"0.03593..."}\times 0.4)$ **or** Expected profit per rod = $\sum(\text{Profit}\times\text{probability})$ $0.30\times\text{"0.849"}+-0.15\times\text{"0.1150..."}+0.20\times\text{"0.03593..."}$ [= 0.2446..]	M1	3.4
	Expected profit per 500 rods $500\times\sum(\text{Profit}\times\text{probability})$ **or** $\sum(\text{Income}\times\text{probability}\times 500)-500\times 0.2$ $=500\times$"0.2446..." **or** = "222.3"-500×0.2	M1d	3.1b
	= [£]122.3... **awrt [£]122**	A1	1.1b
		(5)	
(d)	Let $X\sim \mathrm{B}(200, 0.015)$	M1	3.3
	$\mathrm{P}(X\leqslant 5)=$ / $\mathrm{P}(X\geqslant 6)=$	M1	1.1b
	0.9176... / 0.0824	A1	1.1b
	Manufacturer is unlikely to achieve their aim since $\underline{0.9176<0.95}$ / Manufacturer is unlikely to achieve their aim since $\underline{0.0824>0.05}$	A1ft	2.4
		(4)	

Notes:			(12 marks)
(a)	M1	Using the normal distribution to set up equation. Allow σ for x and awrt ± 1.96	
	A1*	cso For a correct expression for x followed by 0.05 or 0.05000… No incorrect working seen	
(b)	B1	awrt 0.849	
(c)	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) **or** awrt 0.036 (Implied by awrt 18 for number of rods)	
	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) **and** awrt 0.036 (Implied by awrt 18 for number of rods)	
	M1	Correct method to find the total income of 500 rods. Attempt at all 3 with at least two correct and no extras **or** Correct method to find sum of all three profits with at least two of 30, −15 or 20 correct. May work in pence but need to be consistent. Allow awrt 24.5 or 0.245	
	M1d	Dep on previous method for finding profit for 500 rods. May work in pence but need to be consistent. Allow "0.2446..." $\times 500$ or "their income" for 500 rods -500×0.2 (accept 499 or 501)	
	A1	All previous marks must be awarded for awrt 122 awrt 12200p **NB** if uses any integer values for numbers of rods then it is A0 other than for 18 for $L > 8.09$	
(d)	M1	Selecting the appropriate model. May be seen or used. Allow B(200,0.985) or Po(3) Condone B(0.015, 200) or B(0.985, 200).	
	M1	Writing or using $P(X \leqslant 5)$ Do not accept $P(X < 6)$ unless found $P(X \leqslant 5)$	Writing or using $P(X \geqslant 6)$ Do not accept $P(X > 5)$ unless found $P(X \geqslant 6)$
	A1	0.92 (Poisson 0.916…)	0.08 or better
	A1ft	Need at least one of the method marks to be awarded. Correct conclusion with the comparison (may be in words). Ft "their $p = 0.9176$…" as long as $p > 0.9$ If "their 0.9176…" < 0.95 must … be unlikely… If "their 0.9176…" > 0.95 they must say … be likely... To ft the alternative then $p < 0.1$	