Question Number	Scheme	Marks
1	H_0 : The aptitude test result is independent of the test centre H_1 : The aptitude test result is not independent of the test centre	B1

Observed	Pass	Fail	Total	
Centre A	60	30	90	M1
Centre B	80	30	110	
Total	140	60	200	

Expected	Pass	Fail	
Centre A	$\frac{140\times 90}{200}[=63]$	$\frac{60\times 90}{200}[=27]$	M1
Centre B	$\frac{140\times 110}{200}[=77]$	$\frac{60\times 110}{200}[=33]$	

$$\sum\frac{(O-E)^2}{E}=\frac{(60-63)^2}{63}+\frac{(80-77)^2}{77}+\frac{(30-27)^2}{27}+\frac{(30-33)^2}{33}$$

or

$$\sum\frac{O^2}{E}-200=\frac{60^2}{63}+\frac{80^2}{77}+\frac{30^2}{27}+\frac{30^2}{33}-200$$

dM1

$=0.8658\ldots$ awrt 0.866	A1
$\nu=(2-1)(2-1)=1$	B1
$\chi^2_2(0.05)=3.841$	B1ft
[Do not reject H0/not significant/not in the CR] There is insufficient evidence that aptitude test result differs by test centre	dA1ft
	(8)

	Notes	Total 8
	B1	both hypotheses correct with result and centre (Condone aptitude test and test centre). May be written in terms of association
	M1	for a correct contingency table. May be implied by awrt 0.866
	M1	attempt at $\frac{\text{row total }\times\text{column total}}{\text{total}}$ (can be implied by at least one correct expected value)
	dM1	dependent on previous M1. For using $\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}-200$ (There must be 4 values of $\sum\frac{(O-E)^2}{E}$ or $\sum\frac{O^2}{E}$ calculated)
	A1	awrt 0.866
	B1	$\nu=1$
	B1ft	3.841 (or better) allow ft from their stated degrees of freedom
	dA1ft	dependent on 3rd M1 and 3rd B1. For a correct contextual conclusion. Must include result and centre. (Condone aptitude test and test centre)

Question Number	Scheme	Marks
2 (a)	$\mathrm{H}_0 : \rho_s = 0$ $\mathrm{H}_1 : \rho_s > 0$	B1
		(1)
(b)	$[r_s =]1 - \dfrac{6\sum d^2}{5(24)} \geqslant 0.9$	M1 B1
	$\sum d^2 \leqslant 2$ So largest possible value is 2*	A1*
		(3)
(c)	e.g. $d = 0, 0, 0, 1, -1$	M1
	So e.g. $A\ B\ C\ E\ D$	A1
		(2)
	Notes	**Total 6**

(a)	**B1**	for both hypotheses correct in terms of ρ or ρ_s. Condone use of p
(b)	**M1**	for use of formula for r in an equation or an inequality (condone > rather than $\geqslant$)
	B1	for 0.9
	A1*	answer is given so at least one correct line of working is needed between the M mark and the given answer. Allow $\sum d^2 = 2$ if written as an equation throughout but do not allow $\sum d^2 \geqslant 2$ or $\sum d^2 > 2$ or $\sum d^2 < 2$
(c)	**M1**	for a correct possibility for d or $\lvert d \rvert$ May be implied by a correct possibility for rankings
	A1	for a correct possibility for rankings or eg 1, 2, 3, 5, 4

Question Number	Scheme	Marks
3 (a)	$\bar{x} = \left[\dfrac{509.1572 + 510.8428}{2} = \right] 510$	B1
	$2 \times 1.96 \times \dfrac{\sigma}{\sqrt{n}} = 510.8428 - 509.1572$	M1
	$\dfrac{\sigma}{\sqrt{n}} = 0.43$	A1
	$'510' \pm 1.6449 \times '0.43'$	M1 B1
	$(509.292..., 510.707...)$ (awrt 509.3, awrt 510.7)	A1
		(6)
(b)	Let X = The number of confidence intervals containing μ so $X \sim \mathrm{B}(3, 0.9)$	
	$\mathrm{P}(X \geqslant 1) = 1 - \mathrm{P}(X = 0) = 1 - \left[{}^3C_0 \times 0.9^0\right] \times 0.1^3$	M1
	$= 0.999$	A1
		(2)

		Notes (Total 8)
(a)	**B1**	for $\bar{x} = 510$
	M1	for use of $2 \times z \text{ value} \times \dfrac{\sigma}{\sqrt{n}} = 510.8428 - 509.1572$ oe
	A1	Cao
	M1	for use of $\bar{x} \pm z \text{ value} \times \dfrac{\sigma}{\sqrt{n}}$ ft their $\bar{x}$ and their $\dfrac{\sigma}{\sqrt{n}}$
	B1	$z = 1.96$ or better and $z = 1.6449$ or better
	A1	(awrt 509.3, awrt 510.7)
(b)	**M1**	for writing or using $\mathrm{P}(X \geqslant 1) = 1 - \mathrm{P}(X = 0)$ or $\mathrm{P}(X = 1) + \mathrm{P}(X = 2) + \mathrm{P}(X = 3)$
	A1	Cao

Question Number	Scheme	Marks
4 (a)	$\frac{273}{150\times10}=0.18$	M1 A1
		(2)
(b)	${}^{10}C_5\times0.18^5\times0.82^5\times150[=2.65]$ *	B1*
		(1)
(c)	0.54	B1
		(1)
(d)	To ensure that no expected frequency < 5	B1
		(1)
(e)	H_0 : Binomial distribution is a good fit. H_1 : Binomial distribution is not a good fit	B1
	Combine cells 8 + 6 + 3 = 17 and 10.05 + 2.65 + '0.54' = 13.24	M1
	$\sum\frac{(O_i-E_i)^2}{E_i}=2.51+\frac{(17-13.24)^2}{13.24}$	M1
	$=3.5777$ awrt 3.58	A1
	$\nu=5-1-1=3$	B1
	$\chi_3^2(0.05)=6.251$	B1ft
	[Do not reject H_0/not significant] Binomial distribution is a suitable model	dA1
		(7)

		Notes
		Total 12
(a)	**M1**	for a correct method to find the value of p
	A1	Awrt 0.18
(b)	**B1***	for a correct expression for r
(c)	**B1**	for 0.54
(d)	**B1**	for a correct explanation
(e)	**B1**	for both hypotheses correct (any mention of B(10, p) is B0)
	M1	for combining cells
	M1	Dep on an attempt to combine cells. Use of 2.51 + $\sum\frac{(O_i-E_i)^2}{E_i}$ for remaining cells
	A1	awrt 3.58
	B1	$\nu=3$
	B1ft	6.251 or better. Allow ft from their stated DoF
	dA1	dependent on 2nd M1. For a correct conclusion which states that the data are consistent with a binomial distribution which must be consistent with the test statistic and CV (Condone any mention of n and p or it supports the managers belief)

Question Number	Scheme	Marks
5 (a)	$\left[m = \frac{3085}{50} \Rightarrow \right] \quad m = 61.7$	B1
	$v = \frac{190457.2 - 50(61.7)^2}{50-1} = 2.3$	M1 A1
		(3)
(b)	$H_0: \mu_A - \mu_B = 10$ $H_1: \mu_A - \mu_B > 10$	B1
	$z = \frac{72.2 - '61.7' - 10}{\sqrt{\frac{6.4}{50} + \frac{'2.3'}{50}}}$	M1 M1
	$= 1.1986...$ awrt 1.20	A1
	One tailed c.v. $Z = 1.6449$ **or** CR: $Z \geqslant 1.6449$	B1
	Not in CR/Not significant/Do not reject H_0	M1
	No significant evidence to support the **head of department's claim**	A1
		(7)
(c)	Assume that $s^2 = \sigma^2$ for **both** samples	B1
	Assume sample sizes are large enough so that **CLT** applies or the **CLT** allows us to assume that the distributions of the sample means are (approximately) normal	B1
		(2)
	Notes	**Total 12**

(a)	**B1**	Cao
	M1	for a full attempt at s^2 ft their $\bar{x}$
	A1	Cao
(b)	**B1**	for both hypotheses correct in terms of μ_A and μ_B Allow equivalent rearrangements. Allow other letters as long it is clear which is professor A and which is professor B. Must be attached to H_0 and H_1
	M1	for $z = \frac{a - b - 10}{\sqrt{\frac{c}{50} + \frac{d}{50}}}$ with at least 2 of a, b, c or d correct (allow ±) ft their 61.7 and their 2.3
	M1	for $z = \frac{72.2 - '61.7' - 10}{\sqrt{\frac{6.4}{50} + \frac{'2.3'}{50}}}$ (allow ±) ft their 61.7 and their 2.3
	A1	awrt 1.20
	B1	for CV = ±1.6449 and compatible sign with their test statistic
	M1	for correct statement consistent with their test statistic and CV (no contradictory non-contextual comments) May be implied by correct contextual comment on its own
	A1	for a contextual conclusion that is consistent with their test statistic and their CV. Must mention head of department's claim
(c)	**B1**	for one correct assumption. Must mention **both** samples.
	B1	for a second correct assumption. Must mention **both** samples.

Question Number	Scheme	Marks
6 (a)	$\left[\mathrm{P}\left(\bar{H}<55.08\right)=0.1151\right] \Rightarrow \dfrac{55.08-\mu}{\frac{6}{\sqrt{n}}}=-1.20$	M1
	$55.08+\dfrac{7.2}{\sqrt{n}}=\mu$	A1
	$\left[\mathrm{P}\left(\bar{H}>56.976\right)=0.0250\right] \Rightarrow \dfrac{56.976-\mu}{\frac{6}{\sqrt{n}}}=1.96$	M1
	$56.976-\dfrac{11.76}{\sqrt{n}}=\mu$	A1
	$55.08+\dfrac{7.2}{\sqrt{n}}=56.976-\dfrac{11.76}{\sqrt{n}}$	M1
	Either $\dfrac{18.96}{\sqrt{n}}=1.896$ or $\sqrt{n}=10$ leading to n = 100*	A1*
		(6)
(b)	$\mu=55.08+\dfrac{7.2}{'10'}=55.8$ or $\mu=56.976-\dfrac{11.76}{'10'}=55.8$	M1 A1
		(2)
	Notes	**Total 8**

(a)	**M1**	for standardising with μ and $\dfrac{6}{\sqrt{n}}$ and setting = to ± 1.2
	A1	for a correct equation
	M1	for standardising with μ and $\dfrac{6}{\sqrt{n}}$ and setting = to ± 1.96
	A1	for a correct equation
	M1	for solving simultaneously
	A1*	for a correct equation leading to the given answer
(b)	**M1**	substitution of n = their 10 into an equation to find μ
	A1	Cao

Question Number	Scheme	Marks
7 (a)	$E(\bar{X}) = \dfrac{(a-1)+(a+5)}{2} = a+2$	M1 A1
	So $\bar{X}-2$ is an unbiased estimator for a	A1
		(3)
(b)	SE ($\bar{X}-2$) = SE($\bar{X}$)	B1ft
	$\text{Var}(X) = \dfrac{\left((a+5)-(a-1)\right)^2}{12} = 3$	M1 A1
	$\text{SE} = \dfrac{s}{\sqrt{n}} = \dfrac{\sqrt{3}}{3} = 0.57735...$ awrt 0.577	M1 A1
		(5)

	Notes		Total 8
(a)	**M1**	for use of $\dfrac{a+b}{2}$	
	A1	for a + 2	
	A1	Cao	
(b)	**B1ft**	for SE ($\bar{X}-2$) = SE($\bar{X}$) ft their unbiased estimator in part (a) May be implied by awrt 0.577	
	M1	for use of $\dfrac{(b-a)^2}{12}$	
	A1	Cao	
	M1	for use of $\dfrac{s}{\sqrt{n}}$	
	A1	awrt 0.577	

Question Number	Scheme		Marks
8 (a)	$[a =]625+625-886=]364$		B1
	$[b =]42^2+42^2+45^2=5553$		M1 A1
			(3)
(b)	$X = L-3S$		
	$[\text{E}(X)=886-3\times265=]91$		M1
	$[\text{Var}(X)=]45^2+3^2\times78^2=56781$		M1 A1
	$[\text{P}(X>0)=]\text{P}\left(Z>\frac{0-91}{\sqrt{56781}}\right)$		M1
	$[\text{P}(Z>-0.38)=]0.6480$ Cal gives 0.64865… So awrt 0.648 – 0.649		A1
			(5)
(c)	$Y=\frac{S_1-S_2}{2}$	$R=S_1-S_2$	M1
	$\left[\text{E}(Y)=\frac{265-265}{2}=\right]0$	$[\text{E}(R)=265-265=]0$	M1
	$[\text{Var}(Y)=]\frac{78^2+78^2}{4}=3042$	$[\text{Var}(R)=]78^2+78^2=12168$	M1
	$[\text{P}(Y>100)=]\text{P}\left(Z>\frac{100-0}{\sqrt{3042}}\right)$	$[\text{P}(R>200)=]\text{P}\left(Z>\frac{200-0}{\sqrt{12168}}\right)$	M1
	$[\text{P}(Z>1.81)=1-0.9649=]0.0351$ Cal gives 0.0349 So awrt 0.0349 – 0.0351		A1
			(5)

		Notes	Total 13
(a)	**B1**	Cao	
	M1	For writing or using $2\times\text{Var}(M)+\text{Var}(L)$	
	A1	Cao	
(b)	**M1**	for seeing or using E(X) = 91 or correct expression for mean	
	M1	for writing or using $\text{Var}(L)+3^2\text{Var}(S)$	
	A1	Cao	
	M1	for standardising using their mean and standard deviation (Allow ±)	
	A1	awrt 0.648 – awrt 0.649	
(c)	**M1**	for use of $\frac{S_1-S_2}{2}$ or S_1-S_2	
	M1	for writing or using E(Y) = 0 or E(R) = 0	
	M1	for using Var (Y) = 3042 or Var(R) = 12168	
	M1	for standardising using their mean and standard deviation (Allow ±)	
	A1	awrt 0.0349 – awrt 0.0351	