Question Number	Scheme	Marks
1 (a)	e.g. It reduces the potential of bias/favouritism in the selection of the players	B1
		(1)
(b)	[x =] 18	B1
		(1)
(c)	[Probability =] 0	B1
		(1)

	Notes		Total 3
(a)	**B1**	A correct reason referring to reducing bias or favouritism. May say e.g. “will not be selected based on ability” or “everyone has the same chance of being selected”. Condone e.g. “no bias” e.g. to make it fair Do not accept reasons relating to the benefits of taking a sample compared to a census e.g. “accurate”, “fast” but do not withhold the mark if there is a valid reason which is not contradicted by it	
(b)	**B1**	Cao	
(c)	**B1**	0 oe e.g. 0%	

Question Number	Scheme	Marks
2 (a)	$\sum d^2 = 1+4+4+0+0+36+9+4+4+4 [= 66]$	M1
	$r_s = 1 - \dfrac{6\times '66'}{10\left(10^2-1\right)} = 0.6$	M1 A1
		(3)
(b)	$H_0 : \rho = 0 \qquad H_1 : \rho > 0$	B1
	Critical Value $r_s = 0.7455$ or CR: r_s …0.7455	B1
	e.g. Do not reject H_0 **or** e.g. not significant **or** e.g. does not lie in the critical region	M1
	e.g. there is insufficient evidence of a **positive correlation** between the **ranks** of **Judge 1** and **Judge 2**	A1ft
		(4)

	Notes		**Total 7**
(a)	**M1**	For finding the difference between ranks of judge 1 and judge 2 and evaluating $\sum d^2$. May be implied by 66. (Allow one error). May be implied by 0.6 or 0.4	
	M1	For using $1-\dfrac{6\sum d^2}{10(99)}$ with their $\sum d^2$ (this value cannot just be an attempt at adding the differences). May be implied by 0.6	
	A1	0.6 oe (a correct answer scores 3/3)	
(b)	**B1**	For both hypotheses correct. Must be in terms of ρ or ρ_s (condone if it appears as p) Must be attached to H_0 and H_1 (do not accept h for H) Do not allow hypotheses in words on their own.	
	B1	For CV of 0.7455 Allow $\pm$ and do not be concerned by use of a strict or inclusive inequality if a critical region is stated	
	M1	A correct statement independent of hypotheses ft part (a) $\lvert r_s\rvert < 1$ and their CV where $\lvert \text{CV}\rvert < 1$ with compatible signs. No context needed but do not allow contradicting non contextual statements. Condone e.g. "accept H_o", "reject H_1" lies in acceptance region. A correct contextual conclusion may imply this mark.	
	A1ft	Dependent on previous method mark and $\lvert r_s\rvert < \lvert \text{CV}\rvert < 1$. For a correct conclusion suggesting that there is insufficient evidence of a positive correlation between the ranks of the judges. Must mention positive correlation , ranks and the judges oe Condone e.g. "there isn't positive correlation between the ranks of the judges". Follow through their r_s with 0.7455 Note that M0A1ft is not possible. Note that a correct contextual conclusion on its own scores M1A1ft	
	Note	**Two-tailed test** Applying a two-tailed test scores a maximum of B0B0M1A0 allowing access to the M1 mark only	

Question Number	Scheme	Marks
3 (a)	$\frac{36\times35}{250}$	M1
	5.04	A1
		(2)
(b)	H_0 : There is no association between when the car first experienced an engine problem and the type of engine H_1 : There is an association between when the car first experienced an engine problem and the type of engine	B1
	Observed | Expected | $\frac{(O-E)^2}{E}$ 10 | 5.04 | $\frac{(10-'5.04')^2}{'5.04'}(=4.881)$	M1
	$X^2 = 7.444 + '4.881'$	dM1
	$= 12.325$ awrt 12.3	A1
	$\nu = (3-1)(3-1) = 4$ $\quad \chi^2_4(0.05) = 9.488 \Rightarrow$ CR: X^2 …9.488	B1 B1ft
	[In the CR/Significant/Reject H_0] There is evidence of an association between when the car first experienced an engine problem and the type of engine	A1
		(7)

	Notes	**Total 9**
(a)	**M1**	For a correct method for finding the expected value (ignore other values if found)
	A1	5.04 oe isw e.g. if they attempt to find other expected frequencies as well. 5.04 with no incorrect working seen is 2/2
(b)	**B1**	Both hypotheses correct. Engine problems and type of engine mentioned at least once. (may be written in terms of independence (or association) e.g. H_0 : When the car first experienced an engine problem and the type of engine are independent H_1 : When the car first experienced an engine problem and the type of engine are not independent
	M1	For a correct method for finding the contribution to the X^2 value (seen or implied). May be seen in (a) or by the table
	dM1	Dependent on the previous method mark. For finding the test statistic X^2. Usually by adding their value to 7.444 (seen or implied). If they attempt to find the individual values using the table then the method must be correct.
	A1	awrt 12.3 (sight of awrt scores M1dM1A1)
	B1	$\nu = 4$ If not seen then may be implied by 9.488 or 11.143
	B1ft	9.488 or better or ft their DoF (e.g. $\nu = 2$, 5.991 or better or $\nu = 8$, 15.507 or $\nu = 9$, 16.919 or better)
	A1	Dependent on all previous method marks and their X^2 must lie in the critical region i.e. $X^2 >$"9.488" (where $X^2 > 7.444$) A correct contextualised conclusion which is rejecting H_0 Must mention **engine problem** and **type of engine** oe **If hypotheses are the wrong way round, then A0 here**. Do not withhold this mark if their hypotheses are in terms of ρ. Contradictory statements score A0. Condone "relationship" or "connection" here but **not** "correlation".

Question Number	Scheme	Marks
4 (a)	$\left[\bar{y}=\frac{23200}{80}\Rightarrow\right]\ \bar{y}=290$	B1
	$\left[s_y^{\,2}=\right]\frac{6741351-80(290)^2}{80-1}$ or $\left[s_y^{\,2}=\right]\frac{80}{79}\left(\frac{6741351}{80}-\left(\frac{23200}{80}\right)^2\right)$	M1
	$=169$	A1
		(3)
(b)	$H_0:\mu_x-\mu_y=200$ $\quad$ $H_1:\mu_x-\mu_y>200$ oe	B1
	$z=\pm\frac{500-'290'-200}{\sqrt{\frac{'169'}{80}+\frac{1156}{80}}}$	M1 A1ft
	$=2.45718...$ $\quad$ awrt 2.46	A1
	One tailed c.v. $Z=1.6449$ **or** CR: $Z\ldots1.6449$	B1
	e.g. In CR/Significant/Reject H_0	M1
	Sufficient evidence to support the research **student's belief**	A1
		(7)
(c)	Assume that $s^2=\sigma^2$	B1
		(1)
	Notes	**Total 11**

(a)	**B1**	For $\bar{y}=290$
	M1	A correct method for $s_y^{\,2}$. May be implied by 169 on its own (not within a calculation)
	A1	169 do not isw
(b)	**B1**	Both hypotheses correct. Allow equivalent hypotheses. Must be in terms of μ . Use of $\bar{X}-\bar{Y}$ is B0. Allow *g* for *x* and *r* for *y* but use of any other letters must be defined.
	M1	An attempt at $\pm\frac{500-a-200}{\sqrt{\frac{b}{80}+\frac{1156}{80}}}$ oe with at least 1 of *a* or *b* correct using their 290 or their 169 May be implied by awrt ±2.46 or may state e.g. $N\left(\pm200,\frac{'169'}{80}+\frac{1156}{80}\right)$ (μ may be 0)
	A1ft	A correct expression [se $\sqrt{\frac{265}{16}}=4.0697...$] or imp by awrt ±2.46 or *p*-value of awrt 0.0072
	A1	awrt $z=$ 2.46 (possibly $\pm$) or $P(\bar{X}-\bar{Y}>210)=$ awrt 0.00716 Correct answer scores M1A1ftA1 but $200-(500-290)\rightarrow-10$ loses this 2nd A mark
	B1	awrt $\pm$ 1.6449 or better seen or a comparison of *p*-value awrt 0.007 < 0.05 oe
	M1	Dep. on $1<\lvert z\rvert<3$ or $0<P(\bar{X}-\bar{Y}>'210')<0.5$ A correct statement ft on their *z* value and CV, with compatible signs, or prob. Context not needed but do not accept contradicting non contextual comments
	A1	Dep on all **previous M and A marks** but independent of hypotheses. A correct contextual statement e.g. the **mean weight** of **grey squirrels** is **more than 200g greater** than (the mean weight) of **red squirrels** o.e. Must mention **mean weight** at least once if they mention weight or weights. Condone the **difference** (in **mean weights**) is **greater than 200g**
(c)	**B1**	Assume that sample variance = population variance oe (but not e.g. $s_x=s_y$).

Question Number	Scheme	Marks
5 (a)	$\hat{p} = \dfrac{0\times2+1\times40+2\times90+3\times85+4\times30+5\times3}{250\times5}$ or $\hat{p} = \dfrac{40+180+255+120+15}{250\times5}\left(=\dfrac{610}{1250}=\dfrac{122}{250}\right)$	M1
	$=0.488$	A1
		(2)
(b)	$250 - (41.92 + \ldots + 6.92)$	M1
	$= 8.79$	A1
		(2)
(c)	H_0 : Binomial distribution is suitable/sensible (model) H_1 : Binomial distribution is not suitable/sensible (model)	B1
	$\dfrac{(2-'8.8')^2}{'8.8'}[=5.25...]$	M1
	$\left[\sum\dfrac{(O-E)^2}{E}=\right]5.70+'5.25'=10.95$	dM1 A1
	$\nu = 6-1-1=4$	B1
	$\chi^2_4(0.05)=9.488 \Rightarrow$ CR..9.488	B1ft
	[In CR/Significant/Reject H_0] Significant evidence to suggest that a binomial distribution is not a suitable model	A1
		(7)

	Notes	Total 11
(a)	**M1**	For a correct method to find $\hat{p}$ May be implied by 0.488. Allow one error or omission for one of their products.
	A1	0.488 oe e.g. $\dfrac{61}{125}$
(b)	**M1**	For a correct method to find r (Allow $0.512^5\times250$) May be implied by 8.79 or 8.8(0)
	A1	Allow 8.8(0)
(c)	**B1**	Both Hypotheses correct. Must be attached to H_0 and H_1 Do not allow B(5, 0.488) is a suitable model
	M1	For use of $\dfrac{(O-E)^2}{E}$ ft their part (b). If no value is found in (b) or they use 5.7 then M0. May be implied by awrt 5.25 or awrt 10.95 or 10.9 or 11.0
	dM1	Dependent on the first method mark. For 5.70 + '5.25' ft their 5.25 May correctly attempt $\sum\dfrac{(O-E)^2}{E}$ or $\sum\left(\dfrac{O^2}{E}\right)-250$. May be implied by awrt 10.95 or allow 10.9 or 11.0
	A1	awrt 10.95 (allow 10.9 or 11.0)
	B1	4 [degrees of freedom] If not seen then may be implied by 9.488 or 11.143 (or better)
	B1ft	9.488 or better or ft on their dof e.g. 2: 5.991, 3: 7.815, 5: 11.07(0), 6: 12.592
	A1	Dependent on all previous method marks and a critical value > 5 where X^2>CV Requires a correct conclusion rejecting the null hypothesis. Must mention the (binomial) distribution/model

Question Number	Scheme	Marks
6 (a)	e.g. based solely on **known observations** or e.g. contains **no unknown** (population) **parameters**	B1
		(1)
(b)	$\left[\mathrm{E}(R)=\frac{1}{2}\mathrm{E}(X_1)+\frac{3}{4}\mathrm{E}(X_{20})\right]=\frac{1}{2}\mu+\frac{3}{4}\mu$	M1
	$\mathrm{E}(R)=\frac{1}{2}\mu+\frac{3}{4}\mu=\frac{5}{4}\mu\neq\mu$ e.g. So R is a biased estimator for μ	A1
		(2)
(c)	$'\frac{5}{4}\mu'-\mu=\frac{1}{4}\mu$	B1ft
		(1)
(d)	**One of** $a-b=2$ oe **or** $14a+6b=20$ oe **or** $\frac{a-b}{2}=\frac{14a+6b}{20}$ $\left[-4b=a\right]$ oe	B1
	Two of $a-b=2$ oe **,** $14a+6b=20$ oe , $\frac{a-b}{2}=\frac{14a+6b}{20}$ oe	B1
	Solves simultaneously e.g. $14a+6(a-2)=20\Rightarrow a=...,\ b=...$	M1
	a =1.6 oe, b = −0.4 oe	A1
		(4)

		Notes	Total 8
(a)	**B1**	For a correct explanation. Allow a valid explanation which suggests one of the following that it is • based (solely) on observations/calculations/values/information/data oe • contains no unknown (population) parameters • calculated/measured • numerical property of a sample/derived from a sample Do not allow "because it is known" (too vague) but condone "because X_1 and X_{20} are known"	
(b)	**M1**	For use of $\mathrm{E}(R)=a\mathrm{E}(X_1)+b\mathrm{E}(X_{20})$. May be implied by a correct expression or $\frac{5}{4}\mu$	
	A1	Requires an expression in terms of μ before proceeding to a correct simplified value of $\frac{5}{4}\mu$, a reason (e.g. $\neq\mu$) **and** a conclusion (e.g. biased estimator). Must see use of expectation notation e.g. $\mathrm{E}(R)$ or $\frac{1}{2}\mathrm{E}(X_1)+\frac{3}{4}\mathrm{E}(X_{20})$	
(c)	**B1ft**	Follow through their part (b) $-\mu$ Their part (b) must be in terms of μ. May be seen in (b)	
(d)	**B1**	For a correct equation in a and b only. μ must not be present	
	dB1	Dep on 1st B1. For a second different correct equation in a and b only. μ must not be present	
	M1	Dependent on at least one correct equation. For solving simultaneously and proceeding to values for a and b. You do not need to be concerned with the mechanics of the rearrangement as long as values for a and b are achieved. May be implied by a correct value for a or a correct value for b.	
	A1	For correct values of a and b	

Question Number	Scheme	Marks
7 (a)	$\left[\mathrm{P}\left(\bar{X}_n < 45.2\right) = 0.3446\right] \Rightarrow \dfrac{45.2-\mu}{\frac{\sigma}{\sqrt{n}}} = -0.4$ oe	M1
	$45.2 + \dfrac{0.4\sigma}{\sqrt{n}} = \mu$ oe	A1
	$\left[\mathrm{P}\left(\bar{X}_n > 75.2\right) = 0.0179\right] \Rightarrow \dfrac{75.2-\mu}{\frac{\sigma}{\sqrt{n}}} = 2.1$ oe	M1
	$75.2 - \dfrac{2.1\sigma}{\sqrt{n}} = \mu$ oe	A1
	e.g. $45.2 + \dfrac{0.4\sigma}{\sqrt{n}} = 75.2 - \dfrac{2.1\sigma}{\sqrt{n}}$ or e.g. $\dfrac{30}{\frac{\sigma}{\sqrt{n}}} = 2.5$ oe	M1
	$\dfrac{2.5\sigma}{\sqrt{n}} = 30 \Rightarrow \left[\sigma = 12\sqrt{n}\right]$ *	A1*
		(6)
(b)	$\mu = 45.2 + \dfrac{0.4\times 12\sqrt{n}}{\sqrt{n}}$ or $\mu = 75.2 - \dfrac{2.1\times 12\sqrt{n}}{\sqrt{n}}$	M1
	$\mu = 50$	A1
		(2)
(c)	$\dfrac{\sigma}{\sqrt{n}} = \left[\dfrac{12\sqrt{n}}{\sqrt{n}}\right] = 12$	B1
	$\mathrm{P}\left(\bar{X}_n > 59\right) = \mathrm{P}\left(Z > \dfrac{59-'50'}{12}\right)$	M1
	$= 0.2266$ awrt 0.227	A1
		(3)
	Notes	**Total 11**

(a)	**Note**	**If they have not used the tables then maximum score M1A1M1A1M1A0* (5/6)**
	M1	For standardising with μ and $\dfrac{\sigma}{\sqrt{n}}$ and setting = $\pm$awrt 0.4
	A1	For a correct equation with compatible signs. Condone use of e.g. awrt 0.4
	M1	For standardising with μ and $\dfrac{\sigma}{\sqrt{n}}$ and setting = $\pm$awrt 2.1
	A1	For a correct equation with compatible signs. Condone use of e.g. awrt 2.1
	M1	Dependent on at least one correct equation. For solving their 2 equations simultaneously to eliminate μ. Note they may eliminate $\dfrac{\sigma}{\sqrt{n}}$ first to find μ (= 50) and then substitute this back into one of their simultaneous equations which can score this mark.
	A1*	Answer is given so no incorrect working must be seen. They must have an intermediate stage where the equation without μ has the constant terms collected and does not have any fractions within fractions before proceeding to the given answer.

		e.g. $\frac{30}{\frac{\sigma}{\sqrt{n}}} = 2.5 \Rightarrow \frac{25\sigma}{\sqrt{n}} = 300 \Rightarrow \sigma = 12\sqrt{n}$
(b)	**Note**	**If they do not have an equation in (a) involving the standard error $\frac{\sigma}{\sqrt{n}}$ then M0A0**
	M1	For substitution of $\sigma = 12\sqrt{n}$ into an equation for μ. May be implied by 50
	A1	50
(c)	**B1**	Correct SE seen or may be implied e.g. N(...,144) or awrt 0.227
	M1	For standardising using their μ and standard error = 12. Can be implied by awrt 0.227
	A1	awrt 0.227 (correct answer provided no incorrect working seen in (c) scores 3/3)

Question Number	Scheme	Marks
8(a)	$X = S_1 + S_2 + S_3$	
	$[X \sim]\text{N}(54, 0.0027)$ or e.g. $[\text{E}(X) =]54$, $[\text{Var}(X) =]0.0027$	M1 A1
	$\left[\text{P}(X > 54.1) =\right]\text{P}\left(Z > \pm\dfrac{54.1 - '54'}{\sqrt{'0.0027'}}\right)\left[= \text{P}(Z > 1.924...)\right]$	M1
	$[= 1 - 0.9726] = 0.0274$ (Calc 0.02714…) awrt 0.027	A1
		(4)
(b)	$Y = C_1 - C_2$	
	$[Y \sim]\text{N}(0, 0.0018)$ or e.g. $[\text{E}(Y) =]0$, $[\text{Var}(X) =]0.0018$	M1
	$\left[\text{P}(Y > 0.02) =\right]\text{P}\left(Z > \pm\dfrac{0.02 - '0'}{\sqrt{'0.0018'}}\right)\left[= \text{P}(Z > 0.4714...)\right]$	M1
	$[= 1 - 0.6808] = 0.3192$ (Calc 0.31867…) awrt 0.319	A1
	$2 \times \text{P}(Y > 0.02) = 2 \times '0.3192' = 0.6384$ (Calc 0.63735…) awrt 0.637 - awrt 0.638	M1 A1
		(5)
(c)	$T = P_1 + C_1 + ... + C_5 + S_1 + ... + S_{28}$	
	Let $R = T - 30P_1 = C_1 + ... + C_5 + S_1 + ... + S_{28} - 29P_1$ (or e.g. $Q = T - 30P_1 - 190$)	M1 A1
	$[R \sim]\text{N}(194, 33.6697)$ or e.g. $[\text{E}(R) =]194$, $[\text{Var}(R) =]33.6697$ (or $\text{N}(4, 33.6697)$)	M1 A1
	$\left[\text{P}(R < 190) =\right]\text{P}\left(Z < \pm\dfrac{190 - '194'}{\sqrt{'33.6697'}}\right)\left[= \text{P}(Z < -0.68935...)\right]$ (or e.g. $\text{P}(Q < 0)$)	M1
	$[= 1 - 0.7549] = 0.2451$ (Calc 0.2453…) awrt 0.245	A1
		(6)

	Notes		Total 15
(a)	**M1**	For N(54, …) oe seen or used. May see e.g. $[\text{E}(X) =]\ 3 \times 18$. Implied by awrt 0.027	
	A1	For N(54, 0.0027) oe seen or used (Standard deviation (0.05196…) May be seen in their standardisation. The unevaluated expressions for μ and σ^2 can score	
	M1	For standardising with 54.1, their mean $\neq 18$ or 6 and their standard deviation $\neq 0.03$ or 0.0027 (if their mean/or their sd/var are incorrect then working must be shown. Allow $\pm$ stand	
	A1	awrt 0.027 **provided standardisation seen**	
(b)	**M1**	For N(0, 0.0018) oe seen or used e.g. seen in their standardisation. The unevaluated expressions for μ and σ^2 can score. Implied by awrt 0.319 or awrt 0.637– awrt 0.638	
	M1	For standardising with 0.02, their mean and their standard deviation $\neq 0.0018$. Allow $\pm$ stand	
	A1	awrt 0.319 **provided standardisation seen.** May be implied by their final answer	
	M1	For 2 × their 0.319 provided their probability of "0.319" is < 0.5 Imp by correct prob statement	
	A1	**Dep on all previous method marks scored and standardisation seen** awrt 0.637– awrt 0.638	
(c)	**M1**	For sight or use of $T - 30P_1$ may be implied by sight of 194 oe or awrt 33.7 oe. May attempt $T - 30P_1 - 190$ May be implied by sight of 4.	
	A1	for $C_1 + ... + C_5 + S_1 + ... + S_{28} - 29P_1$ oe May be implied by sight of awrt 33.7.	
	M1	For N(194, …) oe seen or used. May be unsimplified. (or N(4, …))	
	A1	For N(194, 33.6697) oe seen or used. The expressions for μ and σ^2 can score. (or N(4,33.6697))	
	M1	For standardising with 190, their mean and their standard deviation $\neq 33.6697$. Allow $\pm$ stand	
	A1	**Dependent on all previous marks scored** for awrt 0.245 **provided standardisation seen**	