adamjee maths

A-LEVEL MATHS / EDEXCEL / FREE RESOURCES

Sampling

Mark scheme

14 questions

Exam questions and marking instructions remain credited to their board.

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3(a)	[Let D = the number of defective components] $D \sim B(36, 0.015)$	M1	3.3
(i)	[$P(D = 2)$ =] 0.084792… awrt **<u>0.0848</u>**	A1	1.1b
(ii)	[$P(D > 3) = 1 - P(D \leq 3) = 1 - 0.9979\ldots$ =] 0.002032… awrt **<u>0.00203</u>**	A1	1.1b
		(3)	
3(b)	[Let X = the number of defective components] $X \sim B(260, 0.015)$	M1	3.3
	[$P(X \geqslant 8)$ =] 0.0441(1…)	A1	1.1b
	[0.04 > 0.025 so not significant] <u>Insufficient</u> evidence that <u>proportion/probability</u> of defective <u>components</u> has <u>changed</u> (o.e.)	A1	2.2b
		(3)	
			(6 marks)

Notes:

(a)	M1	for selecting B(36, 0.015) sight of or use of. Must be B(…) [Implied by sight of Po(0.54)] May be implied by sight of: 0.0848 <u>or</u> awrt 0.085 <u>or</u> 0.00203 <u>or</u> 0.998 <u>or</u> 0.002
(i)	A1	for awrt 0.0848
(ii)	A1	for awrt 0.00203 [Allow 2.03×10^{-3}]
	Use of Poisson Po(0.54) (i) 0.08496 scores A0 (ii) 0.002309… awrt 0.00231 scores A1	
Notation: We do not accept "calculator speak" e.g. $N = 36$, $p = 0.015$ instead of B(36, 0.015)		
(b)	M1	for sight of B(260, 0.015) may be implied by probability of awrt 0.0441 <u>or</u> awrt 0.0264 or awrt 0.956 <u>or</u> correct CR $X = 0$ [or ≤ 0] **and** $X \geq 9$ <u>or</u> $P(X \geq 8) = 0.04$ or better
	A1	for probability of awrt 0.0441 (selected if more probabilities seen) Condone $P(X = 8) = 0.0441\ldots$ If $P(X \geq 8)$ is explicitly seen allow 0.04 or better <u>or</u> for the correct CR $X = 0$ [or ≤ 0] **and** $X \geq 9$. Allow acceptance region [1, 8] (o.e.)
	A1	**dep on M1A1** for a correct conclusion in context. Allow e.g: <u>proportion/probability</u> of defective <u>components</u> has <u>not</u> <u>changed</u> <u>proportion/probability</u> of defective <u>components</u> is still <u>0.015</u> Allow "defectives" instead of "components" If a comparison is seen (other than 0.956 < 0.975) it must be with 0.025 Incorrect comparisons score A0 (condone missing comparison) Do not accept contradictory statements e.g. "significant so insufficient evidence of change in proportion" would score A0 "Insufficient evidence that $p \neq 0.015$" is A0, we need the words.
SC	Poisson Approximation (If you see Po(3.9) or probability 0.0454…)	
	B2 and mark as M0A1A1	
	B1	for probability of awrt 0.0454 <u>or</u> 0.04… if $P(X \geq 8)$ seen <u>or</u> CR as above
	B1	for correct conclusion in context (same rules as above)

Question	Scheme	Marks	AOs

Question	Scheme	Marks	AOs
4(a)	Systematic (sampling)	B1	1.2
		(1)	
4(b)	The (Daily Total) Rainfall data may contain "tr" entries (these will need a suitable value substituted before calculations can take place.)	B1	2.4
		(1)	
4(c)(i)	mm/h (o.e.) e.g. mm h^{-1} or mm hrs^{-1} or $\frac{\text{mm}}{\text{hours}}$	B1	1.1b
(ii)	When there is no sun(shine) there is (on average) 0.7(41) (mm) of rain or the amount of rain when there is no sun(shine) (o.e.)	B1	2.4
		(2)	
4(d)	e.g. Not consistent (since); Kay's line says positive correlation **or** gradient **or** regression coefficient **or** regression line **or** 0.199 is positive	B1	2.4
		(1)	
4(e)	$H_0 : \rho = 0$ and $H_1 : \rho < 0$	B1	2.5
	[*p*-value < 5% so significant result] there is evidence to support the teacher's claim	B1	2.2b
		(2)	
4(f)(i)	The sample is rainfall (*y*) and sunshine (*x*) for May~Oct in (Leeming) in 2015	B1	1.1b
(ii)	e.g. (rainfall and sunshine) for: (Leeming) for all of 2015, or Leeming anytime (not just May~Oct) or Leeming for May~October for other years too or May ~Oct in UK etc	B1	3.3
		(2)	
			(9 marks)

Notes:

(a)	B1	for systematic (ignore other non-contradictory descriptions). Condone misspelling. If a clear choice is given e.g. stratified or systematic we take the final answer.
(b)	B1	for mention of "tr" or "trace" entries in rain(fall) [or *y*] data. Ignore "n/a". Ignore any comment about what to do with trace.
(c)(i)	B1	for mm/h or equivalent in words.
(ii)	B1	for the idea of amount of rain when no sun. "Minimum rain" is B0 Don't need value or units but if given must be correct or consistent with (i)
(d)	B1	for a suitable reason **and** saying not consistent (o.e.) e.g. "false" or "untrue" or "no" Reason only needs to be about the line and may be a description e.g. as *x* increases *y* increases or at least 2 values of *x* substituted and *y* values evaluated
(e)	B1	for both hypotheses correct in terms of ρ (condone attempt at ρ that looks like *p*)
	B1	for a correct conclusion in context with no contradiction. Using words "support" and "teacher's claim" **or** "negative correlation" and "sun or *x*" and "rain or *y*" [If a comparison is given it must be 0.015 < 0.05]
(f)(i)	B1	for recognising that all the data/days for these variables in LDS for 2015 is the sample. Condone omitting "Leeming" B0 for "sunshine and rainfall for Leeming in 2015" It could be the population.
(ii)	B1	for a suitable attempt to describe a population. The teacher's sample must be a subset.

Question	Scheme	Marks	AOs
5(a)(i)	[Let M be the height of a man from the club, P(M > 186) =] 0.270187… = awrt **0.270**	B1	1.1b
(ii)	[P(175 < M < 185) =] 0.6071520… = awrt **0.607**	B1	3.4
		(2)	

Qu 3	Scheme	Marks	AO
(a)	Rain[fall] (allow [Mean] Windspeed)	B1 **(1)**	1.2
(b)	[$\bar{x}$ =] 15.2239… = awrt **15.2**	B1	1.1b
	$\sigma_x = \sqrt{\frac{44\,695.4}{184} - "15.22.."^2}$ or $\sqrt{11.1(422...)}$	M1	1.1b
	= 3.33800… awrt **3.34**	A1 **(3)**	1.1b
(c)	Mean is higher than average **OR** a summer/spring month If they say winter/autumn they must explain that these are hotter months for Perth. [Perth is southern hemisphere or Australia so latest available] month is **Oct**	M1 A1cso **(2)**	2.4 2.2b
		(6 marks)	

	Notes
	Answers may appear next to the question.
(a)	B1 for Rain[fall] or precipitation (e.g. allow Daily Total [or Mean or max] Rainfall etc) (or allow Mean Windspeed or just "windspeed" BUT not max windspeed or "gust") If they give more than one answer we take the **last one**. (NB Actual windspeed mean is 8.2, sd 2.38. No other quantitative variables available)
(b)	B1 for awrt 15.2 (Do not accept fractions or mixed numbers) M1 for a correct expression including square root (ft their mean) May be implied by an answer of 3.3 or better. A1 for awrt 3.34 [Allow s = 3.3471… i.e. awrt 3.35 if correct formula/expression is seen]
	If answer in (b)(i) > 19.4 and an attempt is made in (c) please send to review.
(c)	M1 for a reason mentioning that mean or temperature is higher (o.e.) e.g. it is a warmer/hotter month is OK or sight of 19.4 > (their) 15.2 Only ft their 15.2 if it is less than 19.4 **OR** suggesting a summer/spring month. Ignore incorrect statements that are irrelevant or don't contradict For incorrect statements that contradict score M0 A1cso dep on M1 scored for inferring October Must choose just October not a range like August~October (NB actual mean for Sep is 15.6 and sd 3.19 and this scores A0) Can accept for example "high mean so December" for M1A0
SC	M1A1 for "October since Perth is in the southern hemisphere/Australia" M1A0 for "Sep or Nov or Dec or Jan or Feb **and** "Perth is in the southern hemisphere/Australia" M0A0 just "Perth is in the southern hemisphere/Australia" without a month M0A0

Qu 4	Scheme	Marks	AO
(a)	$H_0 : p = 0.1$ $H_1 : p \neq 0.1$ [Allow 10% for 0.1]	B1	2.5
	[$X \sim B(40, 0.1)$] $\Rightarrow$ $P(X = 0) = 0.0148$ [Allow any letter for X]	M1	3.3
	$P(X \ldots 9) = 1 - P(X \,„\, 8) = 1 - 0.9845 = 0.0155$	A1	1.1b
	Critical region is $\{X = 0\} \cup \{X \ldots 9\}$ (o.e.)	A1	1.1b
		(4)	
(b)	["0.0148" + "0.0155"] = 0.0303	B1ft	1.1b
		(1)	
(c)	[Provided 7 is not in their CR] insufficient evidence to support Freya's belief	B1	2.2b
		(1)	
		(6 marks)	

	Notes
	Mark (a) and (b) together for sight of the probabilities.
(a)	B1 for both hypotheses in terms of p or π. Must be attached to H_0 and H_1
	M1 for use of the correct model. Implied by sight of at least one probability truncated or rounded to at least 2sf from: 0.0155, 0.0148, 0.0805, 0.9845, 0.9581, 0.9949 Implied by sight of fully correct CR (with no probs) so e.g. $X = 0$, $X > 8$ scores M1A0A0
	1st A1 for at least one correct probability (to at least 3sf) with its probability statement i.e. for $P(X = 0)$ = awrt 0.0148 or $P(X \ldots 9)$ = awrt 0.0155
	2nd A1(**dep on M1 and 1st A1** but not on B1) for both correct probs (to at least 3 sf) and the correct critical region Do not need set notation. Allow $X < 1$ and $X > 8$ or words e.g. "0 or greater than 8" etc Allow "," or "and" or "or" or "$\cap$" between $X \,„\, 0$ and $X \ldots 9$ $P(X = 0)$ and $P(X \ldots 9)$ is 2nd A0
(b)	B1ft for awrt 3.03% or correct sum of their two probabilities (provided each is less than 0.5) Their probabilities must be to at least 2sf and relate to their CR
	To score in (c) they must have a CR of the form ($X = 0$ or $X < a$)and $X > b$, where b is …7 **May be implied by $P(X < a)$ and $P(X > b)$ i.e. 2nd A0 in (a) but correct form. Need $b > a$**
(c)	B1 for a suitable comment in context that suggests no support for Freya's belief/claim **or** e.g. insufficient evidence of change in proportion/percentage of left-handed adults **or** e.g. proportion/percentage of left-handed adults is not different from 10% (**or** …is 10%) **or** e.g. 10% of adults in the country are left-handed Do not allow contradictory comments e.g. "in CR so no support for Freya's belief" is B0
NB	A correct contextual answer in (c) using an **acceptance region** please send to review.

Qu 3	Scheme	Marks	AO
(a)	Need to replace tr with a numerical value Value of tr is between 0 and 0.05 suggest using e.g 0.025 , 0 <u>or</u> value „ 0.05	M1 A1 **(2)**	1.2 1.1b
(b)(i)	$\left[\bar{x} = \frac{389.3 \sim 390.8}{184}\right] = 2.119\ldots$ awrt **<u>2.12</u>** allow $\frac{195}{92}$ or $2\frac{11}{92}$	B1	1.1b
(ii)	$\left[\sigma =\right]\sqrt{\frac{(\text{awrt})4336}{184} - "\bar{x}^2"}$ <u>or</u> allow $\left[\sigma^2 =\right]\frac{(\text{awrt})4336}{184} - "\bar{x}^2"$ <u>or</u> awrt 19.1 $= 4.367\ldots$ awrt **<u>4.37</u>**	M1 A1 **(3)**	1.1b 1.1b
(c)(i)	Only covers May~Oct (so not a suitable sample)	B1	1.1b
(ii)	e.g. Winter months are <u>missing</u> when we'd expect <u>more rain</u> so expect estimate in (b)(i) to be an <u>underestimate</u> (oe)	B1 **(2)**	2.4
		(7 marks)	

Notes

(a) M1 for recognising that tr must be replaced (oe) with a numerical value
The following examples would score M0: The tr values are worth 0 so ignore (not replacing) <u>or</u> must remove outliers <u>or</u> fill gaps in table <u>or</u> make widths the same <u>or</u> need to find mid-points
A1 for using a suitable value: e.g. 0.025 (or allow 0) i.e. any value in [0, 0.05]
(these give $\sum x = 390$ (3sf), use of 0.05 gives 390.8, use of 0 gives 389.3 allow in (b)(i))

(b)(i) B1 for awrt 2.12 <u>or</u> allow simplified fraction or mixed number. B0 for $\frac{390}{184}$

(ii) M1 for a correct expression for standard deviation **or** variance. Allow $\sum x^2$ = awrt 4336
Ignore their label σ or σ^2 Can ft their mean

A1 for awrt 4.37 [Use of *s* gives 4.3791… so for correct use seen allow awrt 4.38]

SC **Using *n* = 155** Allow M1 for expression $\left[\sigma =\right]\sqrt{\frac{(\text{awrt})4336}{155} - "\bar{x}^2"} = \sqrt{21.64...}$ or 4.65…

Part (c) can effectively be marked together.

(c)(i) B1 for a comment mentioning that data is just from May~Oct (so not representative of the whole year).
Just saying "only 184 days so not representative" is B0, **must mention May ~ Oct**

(ii) B1 for comment that <u>missing</u>/<u>winter</u> months expected to have more rain (oe) **and** "underestimate"(oe)
We are looking for all 3 of these ideas here:
1. A statement or implication that missing data is from winter or different months.
2. A suggestion about the rainfall in these months (probably more rain).
3. A statement about the impact on the estimate in (b)(i) <u>equivalent</u> to saying it would be an underestimate or the (actual) mean will be higher.

SC If you see "Leeming or N or NE has <u>less</u> rain in winter months" – please send to review

Qu 4	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 $\sigma^2 =$ 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]	A1	2.2b
	Insufficient evidence to support student's claim	**(4)**	
(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 $\lceil \bar{S} \rceil$… 177.248…(awrt 177.25) Allow $\lceil \bar{S} \rceil >$ 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 $\lceil \bar{S} \rceil$… 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

Question	Scheme	Marks	AOs
3(a)	tr	B1	1.2
		(1)	
(b)(i)	$\mu = \frac{174.9}{31} = 5.6419\ldots$ awrt 5.64	B1	1.1b
(ii)	$\sigma_r = \sqrt{\frac{3523.283}{31} - \mu^2}$	M1	1.1b
	$= 9.04559\ldots$ awrt 9.05	A1	1.1b
		(3)	
(c)	Leuchars is in the North and Camborne is in the South	M1	2.4
	The mean is smaller for Leuchars than Camborne therefore there is no evidence that Dian's belief is true	A1ft	2.2b
		(2)	
(d)	eg $p = 0.27$ is unlikely to be constant.	B1	2.4
		(1)	
			(7 marks)

Notes:

(a)	**B1**	Allow Tr or trace or Trace
(b)(i)	**B1**	For a correct mean awrt 5.64
(ii)	**M1**	For a correct expression for sd including the $\sqrt{}$ Ft their mean
	A1	awrt 9.05 (Allow $s = 9.1932\ldots$ awrt 9.19) NB awrt to 9.05 or 9.19 with no working is M1 A1
(c)	**M1**	For stating Leuchars is North of Camborne oe eg Camborne is further south
	A1ft	M1 must be awarded. A correct conclusion **and** correct comment about the means ft their mean in (b) Allow No
	SC	for No **and** there are only 2 places used so there is insufficient data. Mark as M0A1 on epen
(d)	**B1**	A correct reason referring to • independence (needs context as to what is independent) eg consecutive 14 days unlikely to be independent. • probability [of rain] not being constant. • Allow a comment that conveys the idea that the proportion of days with no rain will be different over the year.

Question	Scheme		Marks	AOs
6(a)	eg As the number of minutes exercise (m) increases the resting heart rate (h) decreases **or** the gradient of the curve is becoming flatter with increasing m: diminishing effect of each additional minute of exercise		B1	2.4
			(1)	
(b)	$H_0 : \rho = 0$ $H_1 : \rho < 0$		B1	2.5
	Critical value – 0.3887 (Allow $\pm$)		M1	1.1b
	There is evidence that the product moment **correlation** is **less than 0**/ **there is a negative correlation**		A1	2.2b
			(3)	
(c)	$\log_{10} h = -0.05 \log_{10} m + 1.92$	$h = am^k \rightarrow \log_{10} h = \log_{10} am^k$	M1	1.1b
	$\log_{10} h = -\log_{10} m^{0.05} + 1.92$ or $\log_{10} h = \log_{10} m^{-0.05} + 1.92$ or $h = 10^{1.92 - 0.05 \log_{10} m}$ oe	$\log_{10} h = \log_{10} a + \log_{10} m^k$ or $\log_{10} a = 1.92$	M1	2.1
	$\log_{10} hm^{0.05} = 1.92$ or $\log_{10}\left(\frac{h}{m^{-0.05}}\right) = 1.92$ or $h = 10^{1.92} \times 10^{-0.05 \log_{10} m}$ oe	$\log_{10} h = \log_{10} a + k \log_{10} m$	M1	1.1b
	$hm^{0.05} = 10^{1.92}$ or $\frac{h}{m^{-0.05}} = 10^{1.92}$ or $h = 10^{1.92} \times 10^{\log_{10} m^{-0.05}}$	$\log_{10} a = 1.92$ and $k = -0.05$	M1	1.1b
	$h = 10^{1.92} m^{-0.05}$ or $h = 83.17...m^{-0.05}$ or a = awrt 83.17 **and** $k = -0.05$		A1	1.1b
			(5)	

Notes: **(9 marks)**

(a)	**B1**	eg Idea as one increases the other decreases (in context). Allow use of m and h eg As m increases h decreases. Do not allow negative correlation with no context or $\rho < 0$ Allow there is a negative correlation/association/relationship/exponential between minutes exercise(m) and resting heart rate (h) oe
(b)	**B1**	Both hypotheses correct in terms of ρ (allow p)
	M1	For the cv of -0.3887 or any cv such that $0.3 < \lvert cv \rvert < 0.5$
	A1	Independent of hypotheses. Correct conclusion that implies reject H_0 on basis of seeing – 0.3887 or if they give 0.3887 we must see the comparison 0.3887 < 0.897 **and** which mentions "pmcc/correlation/relationship" and less than 0/ negative or $\rho < 0$ A contradictory statement scores A0 eg Accept H_0 therefore negative correlation
(c)		**In this part once M0 is scored no more marks can be scored. Condone no base**
	M1	**May be implied by 2nd M1 mark** Method 1: Correct substitution for both x and y Method 2 : Taking the log of both sides
	M1	**May be implied by 3rd M1 mark** Method 1: Correct use of the power log rule **or** making h the subject Method 2 : Correct use of the addition/subtraction log rule
	M1	**This line implies M1M1M1** Method 1: Correct use of the addition/subtraction log rule or eq^n in the form $h = 10^{1.92} \times 10^{-0.05 \log m}$ Method 2: A second correct step for correct use of the power log rule
	M1	**This line implies M1M1M1M1** Method 1: Correct removal of logs or $h = 10^{1.92} \times 10^{\log m^{-0.05}}$ Method 2: Log a (or a) and k correct
	A1	Allow h = awrt $83.2m^{-0.05}$ NB award 5/5 for a = awrt 83.2 and $k = -0.05$ or h = awrt $83.2...m^{-0.05}$ or $h = 10^{1.92} m^{-0.05}$

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Qu 1	Scheme	Marks	AO
(a)	**Disadvantage:** e.g. Not random; cannot use (reliably) for inferences	B1 **(1)**	1.1b
(b)	[Sight or correct use of] $X \sim B(36, 0.08)$	M1	3.3
(i)	$P(X = 4) = 0.167387\ldots$ awrt **0.167**	A1	1.1b
(ii)	$[P(X \geqslant 7) = 1 - P(X \leqslant 6) =]$ 0.022233… awrt **0.0222**	A1 **(3)**	1.1b
(c)	P(In dance club and dance tango) = 0.4×0.08 = **0.032** or $\frac{4}{125}$ or **3.2%**	B1 **(1)**	1.1b
(d)	[Let T = those who can dance the Tango. Sight or use of] $T \sim B(50, \text{“}0.032\text{”})$	M1	3.3
	$[P(T < 3) = P(T \leqslant 2) =]$ 0.7850815… awrt **0.785**	A1 **(2)**	1.1b
		(7 marks)	

Notes

(a) B1 for a suitable disadvantage:

Allow (B1)	Do NOT allow (B0)
Not random or less random (o.e.)	Not representative
Cannot use (reliably) for inferences	Less accurate
(More likely to be) biased	Any comment based on time or cost
	Any mention of skew
	Any mention of non-response

(b) M1 for sight of B(36, 0.08) Allow in words: binomial with $n = 36$ and $p = 0.08$
may be implied by one correct answer to 2sf or sight of $P(X \leqslant 6) = 0.97776...$ i.e. awrt 0.98
Allow for $36C4 \times 0.08^4 \times 0.92^{32}$ as this is "correct use"

(i) 1st A1 for awrt 0.167 NB An answer of just awrt 0.167 scores M1($\Rightarrow$)1st A1

(ii) 2nd A1 for awrt 0.0222

(c) B1 for 0.032 o.e. (Can allow for sight of 0.4×0.08)

(d) M1 for sight of B(50, “0.032”) ft their answer to (c) provided it is a probability $\neq 0.08$
may be implied by correct answer
or sight of $[P(T \leqslant 3)] = 0.924348\ldots$ i.e. awrt 0.924 or $P(T \leqslant 2)$ as part of $1 - P(T \leqslant 2)$ calc.
A1 for awrt 0.785

MR Allow MR of 50 (e.g. 30) provided clearly attempting $P(T \leqslant 2)$ and score M1A0

Qu 2	Scheme	Marks	AO
(a)	Negative	B1 **(1)**	1.2
(b)	Marc's suggestion <u>is compatible</u> because it's <u>negative correlation</u>	B1 **(1)**	2.4
(c)	(r =) – 0.54458266… awrt **<u>– 0.545</u>**	B1 **(1)**	1.1b
(d)	$H_0 : \rho = 0$ $H_1 : \rho < 0$	B1	2.5
	[5% 1-tail cv =] (<u>+</u>) 0.4259	M1	1.1a
	(significant result / reject H_0) There <u>is</u> evidence of negative <u>correlation</u> between the <u>number of letters</u> in (or <u>length</u> of) a student's last <u>name</u> and their first <u>name</u>	A1 **(3)**	2.2b
		(6 marks)	

	Notes
(a)	B1 for "negative" Allow "slight" or "weak" etc Allow a description e.g. "as x increases y decreases" or in context e.g. "people with longer last names tend to have shorter first names" A comment of "negative skew" is B0 **Need to see distinct or separate responses for (a) and (b)**
(b)	B1 for a comment that suggests data is compatible with the suggestion **and** a suitable reason such as "there is negative correlation" <u>or</u> a description in x and y or in context <u>or</u> the points lie close to a line with <u>negative gradient</u> <u>or</u> draw line $y = x$ and state that <u>more points below the line</u> so <u>supports (or is compatible with)</u> his suggestion A reason based on just a **single point** is B0 e.g. " 11 letters in last name has only 5 in first name"
(c)	B1 for awrt – 0.545
(d)	B1 for both hypotheses correct in terms of ρ M1 for a critical value compatible with their H_1: 1-tail: awrt <u>+</u> 0.426 (condone <u>+</u> 0.425) **or** 2-tail (B0 scored for H_1) : awrt <u>+</u> 0.497 If hypotheses are in words and can deduce whether one or two-tail then use their words. If no hypotheses or their H_1 is not clearly one or two tail assume one-tail A1 for compatible signs between cv and r **and** a correct conclusion in context mentioning <u>correlation</u> and <u>number of letters</u> or <u>length</u> and <u>name</u> (ft their value from (c)) Do NOT award this A mark if contradictory comments or working seen e.g. "accept H_0" or comparison of 0.426 with significance level of 0.05 etc
NB	The M1A1 can be scored independently of the hypotheses

Qu 3	Scheme	Marks	AO
(a)	Hectopascal <u>or</u> hPa	B1 **(1)**	1.2
(b)	$\overline{x} = \overline{y} + 1010$ <u>or</u> $\frac{214}{30} + 1010$	M1	1.1b
	= 1017.1333… awrt **<u>1017</u>**	A1 **(2)**	1.1b
(c)	$\sigma_x = \sigma_y$ (or statement that standard deviation is not affected by this type of coding)	M1	3.1b
	$\left[\sigma_y =\right] \sqrt{\frac{5912}{30} - (\text{"7.13[33...]"})^2}$ <u>or</u> $\sqrt{146.1822...}$	M1	1.1b
	= 12.0905… awrt **<u>12.1</u>**	A1 **(3)**	1.1b
(d)	High pressure (since approx. mean + sd) so clockwise Locations are (from North to South): Leuchars, Heathrow, Hurn	B1	2.4
	Wind direction is direction wind blows <u>from</u> So: Heathrow (**NE**) Hurn (**E**) Leuchars (**W**)	B1 **(2)**	2.2a
		(8 marks)	

	Notes
FYI	1 hPa = 100 Pa; 10hPa = 1 kPa; 1Pa = 1 Nm^{-2}
(a)	B1 for "hectopascal" <u>or</u> hPa (condone pascals, allow millibars <u>or</u> mb) o.e. Do NOT allow kPa <u>or</u> kilopascals <u>or</u> Pa on its own
(b)	M1 for a strategy to find $\overline{x}$ Allow an attempt to find $\sum x$ that gets as far as $\sum x = \sum y - 30 \times 1010$ [= 30 514] A1 for awrt 1017 (accept 1020) [Ignore incorrect units]
(c)	1st M1 for an overall strategy using the fact $\sigma_x = \sigma_y$ (can be implied by correct <u>final</u> ans) <u>or</u> for $\sum x = 30\,514$ and $\sum x^2 = 31\,041192$ (both seen and correct) 2nd M1 for a correct expression (with $\sqrt{}$)(ft their $\overline{y}$ to 3sf) allow awrt 146 for 146.1822.. <u>or</u> for correct expression in x can ft their $\sum x > 30\,000$ or their answer to (b) A1 (dep on 2nd M1) for awrt 12.1 [Ignore incorrect units]
Final answer	Final ans of awrt 12.1 scores 3/3 **but** if they then adjust for x e.g. add 1010 (M0M1A1)
(d)	1st B1 for at least one of these reasons (these 2 lines) clearly stated (may see diagram) Need "high pressure" **and** "clockwise" to score on 1st line Contradictory statements B0 e.g. correct N~S list but say "anticlockwise" 2nd B1 (indep of 1st B1) for deducing the 3 correct directions either in the table or stated as above If the answers in table and text are different we take the table (as question says)

Qu 5	Scheme	Marks	AO
(a)	$\left[\text{Let } F \sim \text{N}\left(166.5, 6.1^2\right)\right]$ $\text{P}(F < k) = 0.01 \Rightarrow \dfrac{k-166.5}{6.1} = -2.3263$	M1	3.4
	$k = 152.309\ldots$ **<u>152</u>** or awrt **<u>152.3</u>**	A1 **(2)**	1.1b
(b)	[P($150 < F < 175$) =] 0.914840… awrt **<u>0.915</u>**	B1 **(1)**	1.1b
(c)	P($F > 160 \mid 150 < F < 175$)	M1	3.1b
	$= \dfrac{\text{P}(160 < F < 175)}{\text{P}(150 < F < 175)}$ or $\dfrac{\text{P}(160 < F < 175)}{\text{"(b)"}}$	M1	1.1b
	$= \dfrac{0.7749487...}{\text{"0.91484..."}}$	A1ft	1.1b
	= 0.84708… awrt **<u>0.847</u>**	A1 **(4)**	1.1b
(d)	$\text{H}_0 : \mu = 166.5$ $\text{H}_1 : \mu < 166.5$	B1	2.5
	[Let X = height of female from 2nd country] $\bar{X} \sim \text{N}\left(166.5, \left(\dfrac{7.4}{\sqrt{50}}\right)^2\right)$	M1	3.3
	$\text{P}\left(\bar{X} < 164.6\right) = 0.03472...$	A1	3.4
	[0.0347… < 0.05 so significant <u>or</u> reject H_0] There is evidence to support Mia's belief	dA1 **(4)**	2.2b
		(11 marks)	

	Notes
(a)	M1 for standardising (allow <u>+</u>) with k, 166.5 and 6.1 and set equal to a z value $2.3 < \lvert z \rvert < 2.4$ A1 for 152 or awrt 152.3 **Ans only** 2/2 [Condone poor use of notation e.g. $\text{P}(\frac{k-166.5}{6.1}) = -2.3263$] **Allow percentages instead of probabilities throughout.**
(b)	B1 for awrt 0.915
(c)	1st M1 for interpreting demand as an appropriate conditional probability ($\Rightarrow$ by 2nd M1) 2nd M1 for correct ratio of expressions (can ft their (b) on denominator) ($\Rightarrow$ by 1st A1ft) 1st A1ft for a correct ratio of probs (can ft their "0.9148…" to 3sf from (b) if > 0.775) 2nd A1 for awrt 0.847
(d)	B1 for both correct hypotheses in terms of μ 1st M1 for selecting the correct model (needn't use $\bar{X}$ $\Rightarrow$ by standardisation or 1st A1) 1st A1 for correct use of the correct model i.e. awrt 0.035 (allow 0.04 if $\text{P}\left(\text{"}\bar{X}\text{"} < 164.6\right)$ seen) Condone $\text{P}(\text{"}\bar{X}\text{"} > 164.6) = 0.9652$ or awrt 0.97 <u>only if</u> comparison with 0.95 is made
ALT	**Use of *z* value:** Need to see $Z = -1.8(15\ldots)$ **and** cv of <u>+</u> 1.6449 (allow 1.64 or better) for 1st A1
ALT	**Use of CR or CV for $\bar{X}$:** Need to see "$\bar{X}$"< 164.7786… or CV = … (awrt 164.8) for 1st A1 Condone truncation i.e 164.7 or better 2nd dA1 (**dep on M1A1** only) for a correct inference in context. Must mention <u>Mia's belief</u> **or** <u>mean height of females/women</u> Do NOT award if contradictory statements about hypotheses made e.g. "not sig"
SC	**M0 for** $\bar{X}$ ~N(**164.6**, …) If they achieve p = awrt 0.035 (o.e. with z-value or CV of 166.3) **and** a correct conclusion in context is given score M0A0A1 [and SC for awrt 0.97 > 0.95 case]

Qu 2	Scheme	Marks	AO
(a)	Negative	B1 **(1)**	1.2
(b)(i) **(ii)**	Rainfall / mm | or | Pressure / hPa or Pascals or hectopascals or mb or millibars	B1 B1ft **(2)**	2.2b 1.1b
(c)	$H_0 : \rho = 0$ $H_1 : \rho \neq 0$ Critical value: $-0.361(0)$ $r < -0.3610$ so significant result and there is evidence of a correlation between Daily Total Sunshine and Daily Maximum Relative Humidity	B1 M1 A1 **(3)**	2.5 1.1b 2.2b
(d)	Humidity is high and there is evidence of correlation and $r < 0$ So expect amount of sunshine to be lower than the average for Heathrow(oe)	B1 **(1)**	2.2b
		(7 marks)	

Notes

(a) B1 for stating negative. "Negative skew" is B0 though

(b)(i) B1 for mentioning "rainfall" (allow "rain" or "precipitation") or "pressure"
(if more than 1 answer both must be correct)
NB the other quantitative variable for Perth is: Daily Mean Wind Speed and scores B0
[Not allowed "wind speed" since $r = +0.15$ and in winter might expect wind to raise temp]

(ii) B1ft for giving the correct units. If Daily Mean Wind Speed (kn) or knots
"Wind speed" and "knots" would score B0B1 but any other variable scores B0B0

(c) B1 for both hypotheses correct in terms of ρ
M1 for the correct critical value compatible with their H_1: allow $\pm$ 0.361(0)
If the hypotheses are 1-tail then allow cv of $\pm$ 0.3061
e.g. Alternative hypothesis with $r < \pm 0.377$ implies a one-tail test or H_0 and H_1 in words saying "H_0: there is no correlation, H_1: there is correlation" is two-tail
If there are no hypotheses (or they are nonsensical) assume 2-tail so M1 for $\pm$ 0.361(0)

A1 for a correct conclusion in context based on comparing -0.377 with their cv.
Condone incorrect inequality e.g. $-0.3610 < -0.377$ as long as they reject H_0
Do not accept contradictory statements such as "accept H_0 so there is evidence of …"
Can say "support for Stav's belief"(o.e.e.g. "claim") or "evidence of a correlation between sunshine and humidity" condone "negative correlation" or comments such as "if humidity is high amount of sunshine will be low"

(d) B1 for stating low amount of sunshine (o. e.) **and** some reference to $r < 0$ or fog
Check for the following 2 features:
(i) **low** sunshine: allow $\leqslant 5$ hrs (LDS mean for 2015 is 5.3, humidity 97% is 4.1, $\geqslant 97\%$ is 3.1)
(ii) **negative** correlation may be described in words e.g. "high humidity gives low sunshine"
or **fog** (LDS says >95% humidity is foggy) so less sunshine

Qu 1	Scheme	Marks	AO
(a)	c: 0 1 2 3 4 5 6 7 8 P($C = c$): $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$ $\frac{1}{9}$	B1 B1ft (2)	1.2 1.2
(b)	P($C < 4$) = $\frac{4}{9}$ (accept 0.444 or better)	B1 (1)	3.4
(c)	Probability lower than expected suggests model is <u>not</u> good	B1ft (1)	3.5a
(d)	e.g. Cloud cover will vary from month to month and place to place So e.g. use a non-uniform distribution	B1 (1)	3.5c
		(5 marks)	

Notes

(a) 1st B1 for a correct set of values for c. Allow $\left\{\frac{1}{8}, \frac{2}{8}, \ldots \frac{8}{8}\right\}$

2nd B1ft for correct probs from their values for c, consistent with discrete uniform distrib'n
Maybe as a prob. function. Allow P($X = x$) = $\frac{1}{9}$ for $0 \leqslant x \leqslant 8$ provided x = {0, 1, 2, …, 8} is clearly defined somewhere.

(b) B1 for using correct model to get $\frac{4}{9}$ (o.e.)

SC **Sample space {1, …, 8}** If scored B0B1 in (a) for this allow P($C < 4$) = $\frac{3}{8}$ to score B1 in (b)

(c) B1ft for comment that states that the model proposed is or is not a good one based on their model in part (a) and their probability in (b)
|(b) – 0.315| > 0.05 Allow e.g. "it is not suitable"; "it is not accurate" etc
|(b) – 0.315| ⩽ 0.05 Allow a comment that suggests it <u>is</u> suitable
No prob in (b) Allow a comparison that mentions 50% or 0.5 and rejects the model
No prob in (b) and no 50% or 0.5 or **(b) > 1** scores B0
Ignore any comments about location or weather patterns.

(d) B1 for a sensible refinement considering variations in month or location
Just saying "not uniform" is B0
Context & "non-uniform" Allow mention of different locations, months <u>and</u> non-uniform
<u>or</u> use more locations to form a new distribution with probabilities based on frequencies
Context & "binomial" Allow mention of different locations, months <u>and</u> binomial
Just refined model Model must be outlined and discrete and non-uniform
e.g. higher probabilities for more cloud cover <u>or</u> lower probabilities for less cloud cover
Continuous model Any model that is based on a continuous distribution. e.g. normal is B0