adamjee maths

A-LEVEL MATHS / EDEXCEL / FREE RESOURCES

Correlation and regression

Mark scheme

4 questions

Exam questions and marking instructions remain credited to their board.

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1 June 2024 - Paper 3 Statistics - Q2

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Qu 2	Scheme	Marks	AO
(a)	e.g. The height (h) decreases by about 1.28 m for each second of the flight	B1 **(1)**	3.4
(b)	$H_0 : \rho = 0$ $H_1 : \rho < 0$	B1	2.5
	[5% 1-tail cv =] (±) 0.5494	M1	1.1a
	[$r = -0.510$ not sig] there is insufficient (o.e.) evidence of a negative correlation between height (or h) and time (or t)	A1 **(3)**	2.2b
(c)	No – since points seem to follow a curve/quadratic (rather than a line) or since points are "non-linear" but regression line/ model is linear or e.g. between ($t = 5$ and 7)height drops by much more than 2.56 m or e.g. gradient is positive up to $t = 3.5$ (line gradient < 0) or e.g. gradient is positive initially (line gradient < 0) or e.g. gradient is positive and then negative	B1 **(1)**	2.4
(d)	[$h = 38.1 - 0.78\left(t-k\right)^2$ with] a suitable k i.e. in the range 3~4.5	B1 **(1)**	3.3
		(6 marks)	

	Notes
(a)	B1 for a suitable interpretation in context [value can be 1.3 or 1.28 or "just over 1"] per sec Must have underlined words (o.e.) and units "m"or metres and "s" or seconds NB "descends" implies "height decreases" Condone e.g. "decreases by – 1.28 m"
(b)	B1 for both hypotheses correct in terms of ρ [accept a p or p but not r or r] Must be attached to H_0 and H_1 M1 for a critical value corresponding to their H_1: 1-tail: awrt ± 0.549 **or** 2-tail (B0 scored for H_1) : awrt ± 0.632 (tables 0.6319) 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 a correct conclusion in context mentioning correlation and height and time A comparison or statement such as "not sig" is not needed but if seen must be correct. Do NOT award this A mark if contradictory comments or working seen e.g. "reject H_0" or comparison of 0.510 with significance level of 0.05 or e.g. $-0.549 > -0.510$
NB	Can award B0M1A1
SC	**B0(**for 2-tail) **M0**(for cv = ± 0.549) **scored:** Allow 1 mark (score as B0M0A1) for conclusion such as: "insufficient evidence of (negative) correlation between height and time of flight"
(c)	B1 for saying no **and** giving a suitable supporting reason Don't allow "correlation" on its own instead of "gradient" B0 for simply saying "points don't lie close to a straight line" Need mention of curve or some other feature of scatter plot that differs from regression line. B0 for just "non-linear" without mention of the model being linear B0 for simply comparing 1 or 2 points – need a comment about general pattern
(d)	B1 for a value of k in the range [3, 4.5] Do not need $k = \ldots$ Accept a value embedded in Jane's model. ISW any errors in multiplying out bracket.

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 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 2	Scheme	Marks	AO
(a)	$H_0 : \rho = 0$ $H_1 : \rho < 0$	B1	2.5
	Critical value: -0.6215 (Allow any cv in range $0.5 < \lvert cv \rvert < 0.75$)	M1	1.1a
	$r < -0.6215$ so significant result and there is evidence of a negative correlation between w and t	A1	2.2b
		(3)	
(b)	e.g. As temperature increases people spend more time on the beach and less time shopping (o.e.)	B1	2.4
		(1)	
(c)	Since r is close to -1 , it **is** consistent with the suggestion	B1	2.4
		(1)	
(d)	t will be the explanatory variable since sales are likely to depend on the temperature	B1	2.4
		(1)	
(e)	Every degree rise in temperature leads to a drop in weekly earnings of £171	B1	3.4
		(1)	
		(7 marks)	

	Notes
(a)	B1 for both hypotheses in terms of ρ M1 for the critical value: sight of ± 0.6215 or any cv such that $0.5 < \lvert cv \rvert < 0.75$ A1 must reject H_0 on basis of comparing -0.915 with -0.6215 (if $-0.915 < 0.6215$ is seen then A0 but may use $\lvert r \rvert$ o.e. which is fine) and mention "negative", "correlation/relationship" and at least "w" and "t"
(b)	B1 for a suitable reason to explain negative correlation using the context given. e.g. "As temperature drops people are more likely to go shopping (than to the beach)" e.g. "As temperature increases people will be outside rather than in shops" A mere description in context of negative correlation is B0 SO e.g. "As temperature increases people don't want to go shopping/buy clothes" is B0 e.g. "Less clothes needed as temp increases" is B0
(c)	B1 for a suitable reason e.g. "strong"/"significant"/"near perfect" "correlation", $\lvert r \rvert$ close to 1 and saying it is consistent with the suggestion. Allow "yes" followed by the reason.
(d)	B1 For identifying t and giving a suitable reason. Need idea that "w depends on t" or "w responds to t" or "t affects w" (o.e.) Allow t (temperature) affects the other variable etc Just saying " t is the independent variable" or "t explains change in w" is B0 N. B. Suggesting causation is B0 e.g. "t causes w to decrease"
(e)	B1 for a description that conveys the idea of rate per degree Celsius. Must have 171, condone missing "£" sign.