A Level Statistics

AQA Past Exam Questions

TOPIC: Hypothesis Testing
Paired t Test

Candidates may use any calculator allowed by Pearson regulations. Calculators must not have retrievable mathematical formulae stored in them.

Instructions

• Use **black** ink or ball-point pen.

• If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.

• **Fill in the boxes** at the top of this page with your name, centre number and candidate number.

• Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.

• Answer the questions ***on paper***

• You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

• Unless otherwise stated, statistical tests should be carried out at the 5% significance level.

• When a calculator is used, the answer should be given to three significant figures unless otherwise stated.

Information

• ***You may use the*** booklet 'Statistical Formulae and Tables'

• There are **8** questions in this question paper. The total mark for this paper is ***72***

• The marks for **each** question are shown in brackets – use this as a guide as to how much time to spend on each question.

Advice

• Read each question carefully before you start to answer it.

• Try to answer every question.

• Check your answers if you have time at the end.

• If you change your mind about an answer, cross it out and put your new answer and any working underneath.

• Check your answers if you have time at the end.

AQA_JUNE_2018_3a

Q3	Solution	Mark	Total	Comment
(a) (i)	H_o pop mean diff $\mu_d = 0$ H_1 pop mean diff $\mu_d > 0$ [Before – After] 1 tail 5%	B1		Hypotheses consistent with *d*
	d = Before - After A: 0.8; B: - 0.3; C: 0.6; D: 1.9; E: 0.3; F: 2.6 G: 0.9; H: -0.9; I: -0.7; J: 1.6	M1 A1		Differences (ignore signs) At least 8 correct differences
	$\bar{d} = 0.68$ $s = 1.135$ $n = 10$	m1		Attempt to evaluate $\bar{d}$ and s Condone 1.0768 here
	$t = \frac{0.68 - 0}{1.135/\sqrt{10}} = 1.89$	m1 A1		Wholly correct method for *t* (condone small slip in $\bar{d}$, s) (±) 1.89 (1.85 – 1.95) or *p* =0.0453
	df = 9 cv = 1.833 1.833 < 1.89 or 0.0453<0.05	B1		for correct cv or *p* compared with 0.05
	Reject H_o	A1dep		correct conclusion dep ts/cv correct
	Significant evidence to suggest that after the introduction of the bonus/ (scheme) there was a reduction in the mean absenteeism level.	E1dep	9	correct conclusion in context Not too definite
(ii)	Differences in absenteeism levels are normally distributed	B1	1	Normally distributed with some context.

AQA_JUNE_2017_1a

Q1	Solution	Marks	Total	Comments
(a)	H_0 pop mean diff $\mu_d = 0$ H_1 pop mean diff $\mu_d > 0$ 1 tail 1% d = *Robusta - Arabica*	B1		Hypotheses
	A 133, **B** 104, **C** -87, **D** -86, **E** 142 **F** 101, **G** 185, **H** 167, **I** 209, **J** 97	M1		Differences (consistent with H_1) At least 5 correct differences
	$\bar{d} = 96.5$ $s = 103.2$ $n = 10$	m1dep		Attempt to evaluate $\bar{d}$ and s
	$t = \dfrac{96.5 - 0}{103.2/\sqrt{10}} = 2.96$	B1 m1 A1		Use of $\dfrac{s}{\sqrt{n}}$ ft in ts $n = 9$ or 10 Method for t (±) 2.96 (2.85 – 3.05) or p=0.008
	df = 9 cv = 2.821 2.96 > 2.821	B1		for correct cv or p = 0.00803 < 0.01 gains M1m1B1m1A1B1
	Reject H_0 Significant **evidence** to suggest **Robusta** produces a **higher mean/average yield** of green beans. Or Scientist's **belief supported** by given data	E1dep	**8**	correct conclusion in context 1 tail

AQA_JUNE_2015_2a

<table>
<tr><th>Q2</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>(a)(i)</td><td>Assume that differences in pulse/rate measurements are normally distributed and that the 12 people can be regarded as a random sample.</td><td>E1

E1</td><td>2</td><td>

Normal dist and random sample in context</td></tr>
<tr><td>(ii)</td><td>H_o pop mean diff/ μ_d = 0
H_1 pop mean diff/ $\mu_d \neq 0$
2 tail 5%

d = After - before
<table>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>d</td><td>5</td><td>6</td><td>1</td><td>0</td><td>-1</td><td>0</td></tr>
<tr><td></td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>d</td><td>5</td><td>1</td><td>-1</td><td>-5</td><td>4</td><td>2</td></tr>
</table>
$\bar{d}$ = 1.417 s = 3.175 n = 12

$t = \frac{1.417-0}{3.173/\sqrt{12}}$ = 1.545

df = 11 cv = ± 2.201
1.545 < 2.201

Accept H_o

No significant evidence to suggest that there is a difference in average pulse rates before and immediately after minor dental treatment</td><td>B1

M1

m1dep diffs

M1

A1

B1

A1

E1</td><td>8</td><td>Hypotheses

sc 0's ignored B1 M1 m1 M1 only

Differences – can be reverse sign

attempt to find $\bar{d}$, s seen/labelled

Use of $\frac{s}{\sqrt{12}}$ ft on 's'
(±) 1.54 or 1.55 (1.53 – 1.56)

(or p =0.15 compared with 0.025) for correct cv

Correct conclusion with consistent comparison

Correct conclusion in context</td></tr>
<tr><td>(iii)</td><td>Type II error</td><td>B1</td><td>1</td><td></td></tr>
</table>

AQA_JUNE_2016_2a

Q2	Solution	Marks	Total	Comments
(a)	H_0 pop mean diff or $\mu_d = 0$ H_1 pop mean diff or $\mu_d > 0$ [QC – DD] 1 tail 5%	B1		Hypotheses consistent with d
	d = QC - DD **A** +5, **B** 0, **C** +4, **D** +3, **E** -1, **F** -1 **G** +4, **H** +2, **I** +8, **J** +4, **K** +9, **L** +2	M1 A1		Differences (ignore signs) At least 8 correct differences PI
	$\bar{d} = 3.25$ $s = 3.166$ $n = 12$	m1dep		Attempt to evaluate $\bar{d}$ and s sc 0 excluded gives $\bar{d} = 3.545$ M1A1m1 max
	$t = \frac{3.25-0}{3.166/\sqrt{12}} = 3.56$	B1 m1 A1		Use of $\frac{s}{\sqrt{n}}$, n =12 ft in ts oe PI Method for t (±) 3.56 (3.50 – 3.60)
	df = 11 cv = **1.796** 1.796 < 3.56	B1		for correct cv Allow p value = 0.00225(for m1 B1 m1A1) compared with 0.05(B1)
	Reject H_0	A1 dep		correct conclusion
	Significant evidence to suggest that: the belief is correct OR the time taken, after placing on ward, before a box of *Chok Delights* is opened is, on average, less than that for a box of *Quality Chox*	E1dep	**10**	correct conclusion in context

AQA_JUNE_2014_1

Q	Solution	Marks	Total	Comments
1(a)	16 birds/feathers can be regarded as a random sample. Differences in yellowness index can be assumed to be normally distributed.	E1 E1	2	At least one in context for E2 sc B1 for both reasons, no context
1(b)	H_0 pop mean diff $\mu_d = 0$ H_1 pop mean diff $\mu_d > 0$ 1 tail 1%	B1		Consistent with differences Odd – Typical H_1 $\mu_d < 0$
	d = Typical - Odd			
	$\bar{d} = 0.137$ $s = 0.135$ $n = 16$	m1dep		attempt to find $\bar{d}$, s
	$t = \dfrac{0.137 - 0}{0.135/\sqrt{16}} = 4.05$ to 4.07	M1 m1ft		Use of $\dfrac{s}{\sqrt{16}}$ ft
		A1		(±) 4.06
	df = 15 |cv|=**2.602**	B1		cao cv p=0.00051 comp 1%
	Reject H_0 Significant evidence to suggest that odd tail feathers are less yellow than typical feathers.	A1dep E1dep		dep correct ts and cv(both + or both -) In context dep A1
			10	

	1	2	3	4	5	6	7	8
d	+ .069	- .028	+ .109	- .041	- .018	+ .014	+ .249	+ .08
	9	10	11	12	13	14	15	16
d	+ .032	+ .189	+ .119	+ .37	+ .386	+ .241	+ .183	+ .238

AQA_JUNE_2013_1a

Q	Solution	Marks	Total	Comments
1(a)(i)	H_0 pop mean diff $\mu_d = 0$ H_1 pop mean diff $\mu_d \neq 0$ 2 tail 5%	B1		Must refer to pop mean differences or μ_d
	d = K – EMC **1** –0.4, **2** 0.8, **3** -0.4, **4** –0.5, **5** 0.1 **6** –0.8, **7** -0.5, **8** 0, **9** –0.6, **10** 0.1	M1		Differences – can be reversed
	$\bar{d} = -0.22$ $s = 0.471$ $n = 10$	m1		attempt to find $\bar{d}$, s can be implied
	$t = \dfrac{-0.22 - 0}{0.47/\sqrt{10}} = \mathbf{-1.48}$	m1 m1 A1		Use of $\dfrac{s}{\sqrt{10}}$ ft Method for t (±) 1.48 (1.46 – 1.48)
	df = 9 cv = **–2.262** –2.262 < –1.48	B1		for correct cv (or p =0.17 > 0.05 B1)
	Accept H_0			*sc4 '0' ignored scores B1 M1m1m1 $\dfrac{s}{\sqrt{9}}$
	No significant evidence to suggest that there is a difference in mean measurements for the two devices.	E1	8	correct conclusion in context
(ii)	Assumed that **differences** in first ray **foot measurements** are **normally** distributed	E1 E1	2	Normal distribution mentioned in a sentence E1 Differences in foot measurements are normal gains other E1

AQA_JUNE_2012_3a

Q	Solution	Marks	Total	Comments
3(a)(i)	H_0 pop mean diff $\mu_d = 5$ H_1 pop mean diff $\mu_d > 5$ 1 tail 10%	B1		H_0 pop mean diff $\mu_d = 5$ H_1 pop mean diff $\mu_d < -5$ H_1 must be consistent with d
	d = Brand – Sup Own **1** +7, **2** +13, **3** –1, **4** +6, **5** –4 **6** +16, **7** +1, **8** +5	M1		Differences (can be reversed)
	$\bar{d} = 5.375 \quad s = 6.781 \quad n = 8$	m1		Attempt to find $\bar{d}$, s can be implied by correct ts
	$t = \dfrac{5.375 - 5}{6.781/\sqrt{8}} = 0.156$	M1		Use of $\dfrac{s}{\sqrt{8}}$ ft
		M1 m1 A1		Use of $\bar{x} - 5$ or $\bar{x} + 5$ Whole method for t $(\pm)0.156$ (0.15–0.16) SC $t = -4.3275$ B3
	df = 7 $\quad$ |cv| = 1.415	B1		For correct consistent cv CAO
	0.156 < 1.415 Accept H_0 Significant evidence to suggest that claim is correct.	E1	9	Clear correct conclusion in context of claim or jam contents
(ii)	Assumed that differences in jar jam contents are normally distributed and	E1		Diffs of contents / jam normal
	samples of jars are obtained at random.	E1	2	Jars obtained at random