adamjee maths

A-LEVEL MATHS / EDEXCEL / FREE RESOURCES

# Data presentation and interpretation

## Question paper

13 questions

Exam questions and marking instructions remain credited to their board.

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**2.** Runners in an athletics club can train with either coach *A* or coach *B* for the 400 m race.

Coach *A* trains 120 runners for the 400 m and records the best time, $x$ seconds, for each runner.

The results are summarised by the following statistics

$$\sum x = 6612 \qquad \sum x^2 = 364902$$

(a) Calculate the mean of the best times for the runners trained by coach *A*

**(1)**

(b) Calculate the standard deviation of the best times for the runners trained by coach *A*

**(2)**

The mean and standard deviation for the best times of the 100 runners trained for the 400 m by coach *B* are 55.1 seconds and 3.6 seconds respectively.

A 400 m race consists of equal numbers of the fastest runners trained by coach *A* and by coach *B*

(c) State, giving a reason, which coach is more likely to have trained the winner.

**(2)**

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**Question 2 continued**

**(Total for Question 2 is 5 marks)**

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**5.** The heights of men in a tennis club are normally distributed with a mean of 183 cm and a standard deviation of 4.9 cm.

A man from the tennis club is selected at random.

(a) Find the probability that the man's height is

(i) more than 186 cm,

(ii) between 175 cm and 185 cm.

**(2)**

The heights of women in the tennis club are normally distributed with a mean of $\mu$ cm and a standard deviation of $\sigma$ cm.

Given that 40% of the women are shorter than 170 cm and 15% are taller than 175 cm,

(b) find the value of $\mu$ and the value of $\sigma$
Show your working clearly.

**(5)**

A man from the tennis club and a woman from the tennis club are selected at random.

(c) Find the probability that both players have heights between 170 cm and 175 cm.

**(3)**

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**Question 5 continued**

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**Question 5 continued**

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**Question 5 continued**

**(Total for Question 5 is 10 marks)**

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**3.** Ming is studying the large data set for Perth in 2015

He intended to use all the data available to find summary statistics for the Daily Mean Air Temperature, $x$ °C.
Unfortunately, Ming selected an incorrect variable on the spreadsheet.
This incorrect variable gave a mean of 5.3 and a standard deviation of 12.4

(a) Using your knowledge of the large data set, suggest which variable Ming selected.

**(1)**

The correct values for the Daily Mean Air Temperature are summarised as

$n = 184$ $\quad \sum x = 2801.2$ $\quad \sum x^2 = 44\,695.4$

(b) Calculate the mean and standard deviation for these data.

**(3)**

One of the months from the large data set for Perth in 2015 has

- mean $\bar{x} = 19.4$
- standard deviation $\sigma_x = 2.83$

for Daily Mean Air Temperature.

(c) Suggest, giving a reason, a month these data may have come from.

**(2)**

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**Question 3 continued**

**(Total for Question 3 is 6 marks)**

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**5.** The records for a school athletics club show that the height, $H$ metres, achieved by students in the high jump is normally distributed with mean 1.4 metres and standard deviation 0.15 metres.

(a) Find the proportion of these students achieving a height of more than 1.6 metres.

**(1)**

The records also show that the time, $T$ seconds, to run 1500 metres is normally distributed with mean 330 seconds and standard deviation 26 seconds.

The school's Head would like to use these distributions to estimate the proportion of students from the school athletics club who can jump higher than 1.6 metres **and** can run 1500 metres in less than 5 minutes.

(b) State a necessary assumption about $H$ and $T$ for the Head to calculate an estimate of this proportion.

**(1)**

(c) Find the Head's estimate of this proportion.

**(3)**

Students in the school athletics club also throw the discus.

The random variable $D \sim \mathrm{N}\left(\mu, \sigma^2\right)$ represents the distance, in metres, that a student can throw the discus.

Given that $\mathrm{P}(D < 16.3) = 0.30$ and $\mathrm{P}(D > 29.0) = 0.10$

(d) calculate the value of $\mu$ and the value of $\sigma$

**(5)**

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**Question 5 continued**

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**3.** Ben is studying the Daily Total Rainfall, $x$ mm, in Leeming for 1987

He used all the data from the large data set and summarised the information in the following table.

| $x$ | 0 | 0.1–0.5 | 0.6–1.0 | 1.1–1.9 | 2.0–4.0 | 4.1–6.9 | 7.0–12.0 | 12.1–20.9 | 21.0–32.0 | tr |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency | 55 | 18 | 18 | 21 | 17 | 9 | 9 | 6 | 2 | 29 |

(a) Explain how the data will need to be cleaned before Ben can start to calculate statistics such as the mean and standard deviation.

**(2)**

Using all 184 of these values, Ben estimates $\sum x = 390$ and $\sum x^2 = 4336$

(b) Calculate estimates for

(i) the mean Daily Total Rainfall,

(ii) the standard deviation of the Daily Total Rainfall.

**(3)**

Ben suggests using the statistic calculated in part (b)(i) to estimate the annual mean Daily Total Rainfall in Leeming for 1987

(c) Using your knowledge of the large data set,

(i) give a reason why these data would not be suitable,

(ii) state, giving a reason, how you would expect the estimate in part (b)(i) to differ from the actual annual mean Daily Total Rainfall in Leeming for 1987

**(2)**

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**Question 3 continued**

**(Total for Question 3 is 7 marks)**

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**4.** A study was made of adult men from region *A* of a country.
It was found that their heights were normally distributed with a mean of 175.4 cm and standard deviation 6.8 cm.

(a) Find the proportion of these men that are taller than 180 cm.

**(1)**

A student claimed that the mean height of adult men from region *B* of this country was different from the mean height of adult men from region *A*.

A random sample of 52 adult men from region *B* had a mean height of 177.2 cm

The student assumed that the standard deviation of heights of adult men was 6.8 cm both for region *A* and region *B*.

(b) Use a suitable test to assess the student's claim.
You should

- state your hypotheses clearly
- use a 5% level of significance

**(4)**

(c) Find the *p*-value for the test in part (b)

**(1)**

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**Question 4 continued**

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**6.** A medical researcher is studying the number of hours, $T$, a patient stays in hospital following a particular operation.

The histogram on the page opposite summarises the results for a random sample of 90 patients.

(a) Use the histogram to estimate $P(10 < T < 30)$

**(2)**

For these 90 patients the time spent in hospital following the operation had

- a mean of 14.9 hours
- a standard deviation of 9.3 hours

Tomas suggests that $T$ can be modelled by $N(14.9, 9.3^2)$

(b) With reference to the histogram, state, giving a reason, whether or not Tomas' model could be suitable.

**(1)**

Xiang suggests that the frequency polygon based on this histogram could be modelled by a curve with equation

$$y = kxe^{-x} \quad 0 \leqslant x \leqslant 4$$

where

- $x$ is measured in **tens of hours**
- $k$ is a constant

(c) Use algebraic integration to show that

$$\int_0^n xe^{-x}\,dx = 1 - (n+1)e^{-n}$$

**(4)**

(d) Show that, for Xiang's model, $k = 99$ to the nearest integer.

**(3)**

(e) Estimate $P(10 < T < 30)$ using

(i) Tomas' model of $T \sim N(14.9, 9.3^2)$

**(1)**

(ii) Xiang's curve with equation $y = 99xe^{-x}$ and the answer to part (c)

**(2)**

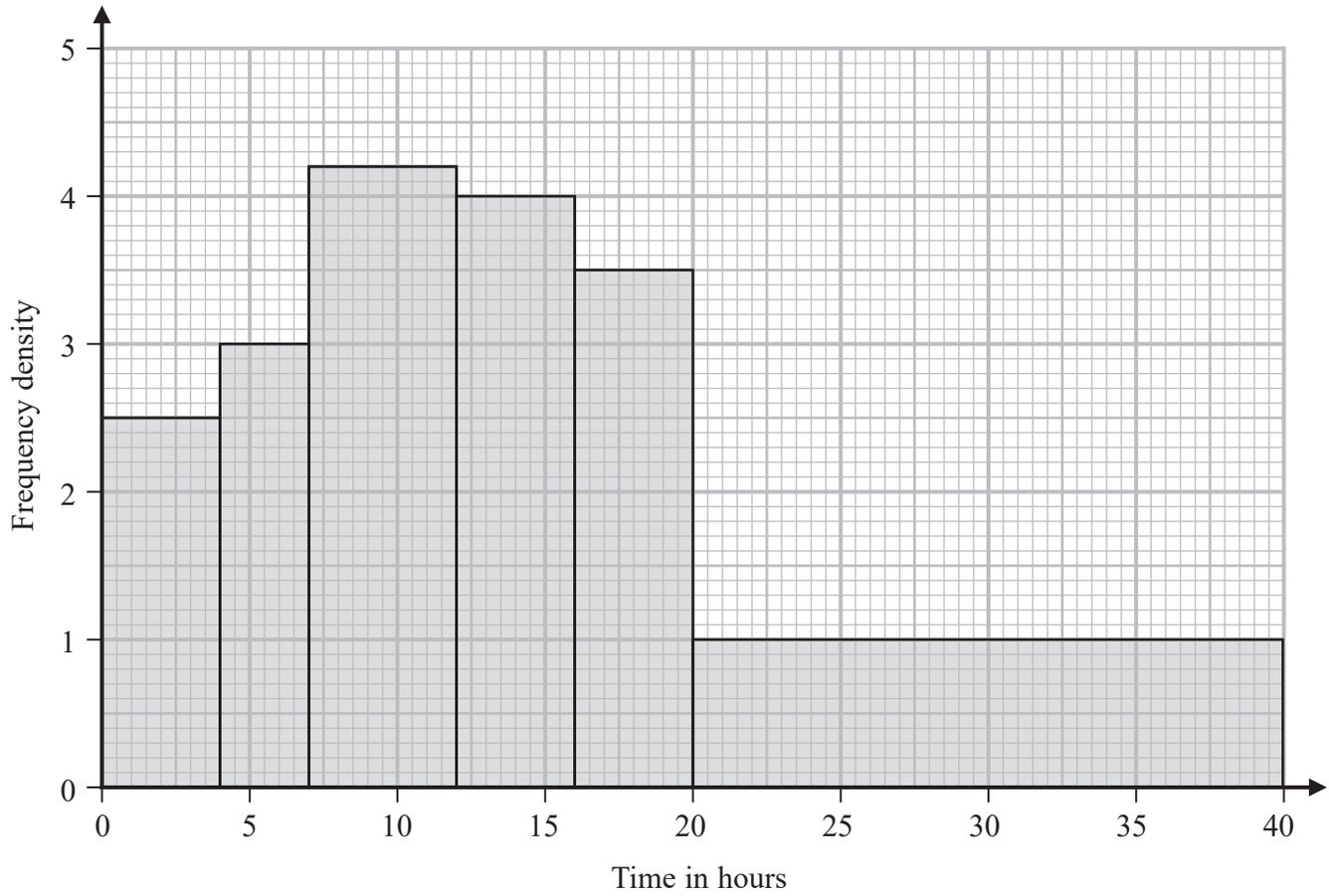
The researcher decides to use Xiang's curve to model $P(a < T < b)$

(f) State one limitation of Xiang's model.

**(1)**

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**Question 6 continued**




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**Question 6 continued**

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**Question 6 continued**

**(Total for Question 6 is 14 marks)**

**TOTAL FOR STATISTICS IS 50 MARKS**

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**5.** The heights of females from a country are normally distributed with

- a mean of 166.5 cm
- a standard deviation of 6.1 cm

Given that 1% of females from this country are shorter than $k$ cm,

(a) find the value of $k$

**(2)**

(b) Find the proportion of females from this country with heights between 150 cm and 175 cm

**(1)**

A female, from this country, is chosen at random from those with heights between 150 cm and 175 cm

(c) Find the probability that her height is more than 160 cm

**(4)**

The heights of females from a different country are normally distributed with a standard deviation of 7.4 cm

Mia believes that the mean height of females from this country is less than 166.5 cm

Mia takes a random sample of 50 females from this country and finds the mean of her sample is 164.6 cm

(d) Carry out a suitable test to assess Mia's belief.
You should

- state your hypotheses clearly
- use a 5% level of significance

**(4)**

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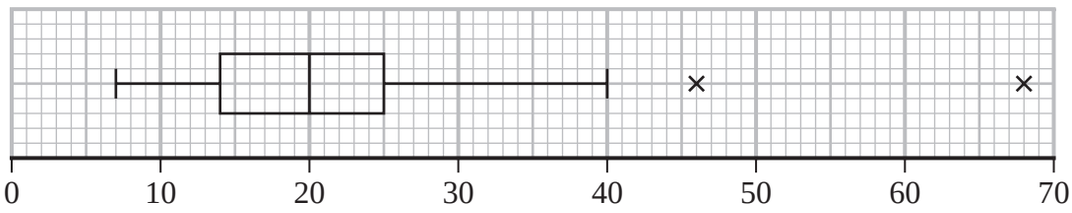
**(Total for Question 5 is 11 marks)**

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**3.** Each member of a group of 27 people was timed when completing a puzzle.

The time taken, $x$ minutes, for each member of the group was recorded.

These times are summarised in the following box and whisker plot.




**Time ($x$ minutes)**

(a) Find the range of the times.

**(1)**

(b) Find the interquartile range of the times.

**(1)**

For these 27 people $\sum x = 607.5$ and $\sum x^2 = 17\,623.25$

(c) calculate the mean time taken to complete the puzzle,

**(1)**

(d) calculate the standard deviation of the times taken to complete the puzzle.

**(2)**

Taruni defines an outlier as a value more than 3 standard deviations above the mean.

(e) State how many outliers Taruni would say there are in these data, giving a reason for your answer.

**(1)**

Adam and Beth also completed the puzzle in $a$ minutes and $b$ minutes respectively, where $a > b$.
When their times are included with the data of the other 27 people

- the median time increases
- the mean time does not change

(f) Suggest a possible value for $a$ and a possible value for $b$, explaining how your values satisfy the above conditions.

**(3)**

(g) Without carrying out any further calculations, explain why the standard deviation of all 29 times will be lower than your answer to part (d).

**(1)**

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**Question 3 continued**

**Question 3 continued**

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**Question 3 continued**

**(Total for Question 3 is 10 marks)**

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**5.** A health centre claims that the time a doctor spends with a patient can be modelled by a normal distribution with a mean of 10 minutes and a standard deviation of 4 minutes.

(a) Using this model, find the probability that the time spent with a randomly selected patient is more than 15 minutes.

**(1)**

Some patients complain that the mean time the doctor spends with a patient is more than 10 minutes.

The receptionist takes a random sample of 20 patients and finds that the mean time the doctor spends with a patient is 11.5 minutes.

(b) Stating your hypotheses clearly and using a 5% significance level, test whether or not there is evidence to support the patients' complaint.

**(4)**

The health centre also claims that the time a dentist spends with a patient during a routine appointment, $T$ minutes, can be modelled by the normal distribution where $T \sim \mathrm{N}(5, 3.5^2)$

(c) Using this model,

(i) find the probability that a routine appointment with the dentist takes less than 2 minutes

**(1)**

(ii) find $\mathrm{P}(T < 2 \mid T > 0)$

**(3)**

(iii) hence explain why this normal distribution may not be a good model for $T$.

**(1)**

The dentist believes that she cannot complete a routine appointment in less than 2 minutes.

She suggests that the health centre should use a refined model only including values of $T > 2$

(d) Find the median time for a routine appointment using this new model, giving your answer correct to one decimal place.

**(5)**

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**Question 5 continued**

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**Question 5 continued**

**(Total for Question 5 is 15 marks)**

**TOTAL FOR STATISTICS IS 50 MARKS**

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**2.**

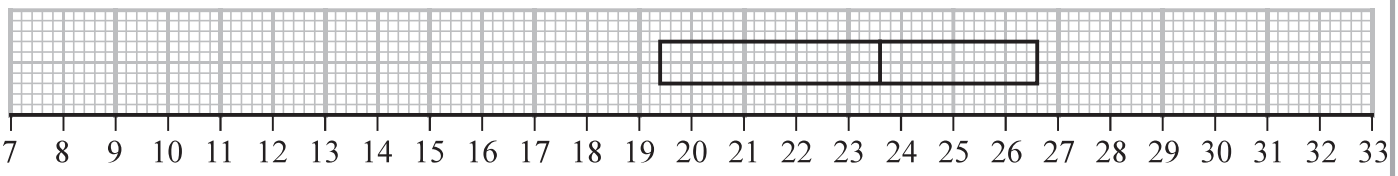



**Figure 1**

The partially completed box plot in Figure 1 shows the distribution of daily mean air temperatures using the data from the large data set for Beijing in 2015

An outlier is defined as a value
more than 1.5 × IQR below $Q_1$ or
more than 1.5 × IQR above $Q_3$

The three lowest air temperatures in the data set are 7.6 °C, 8.1 °C and 9.1 °C
The highest air temperature in the data set is 32.5 °C

(a) Complete the box plot in Figure 1 showing clearly any outliers.

**(4)**

(b) Using your knowledge of the large data set, suggest from which month the two outliers are likely to have come.

**(1)**

Using the data from the large data set, Simon produced the following summary statistics for the daily mean air temperature, $x$ °C, for Beijing in 2015

$$n = 184 \qquad \sum x = 4153.6 \qquad S_{xx} = 4952.906$$

(c) Show that, to 3 significant figures, the standard deviation is 5.19 °C

**(1)**

Simon decides to model the air temperatures with the random variable

$$T \sim N(22.6, 5.19^2)$$

(d) Using Simon's model, calculate the 10th to 90th interpercentile range.

**(3)**

Simon wants to model another variable from the large data set for Beijing using a normal distribution.

(e) State two variables from the large data set for Beijing that are **not** suitable to be modelled by a normal distribution. Give a reason for each answer.

**(2)**

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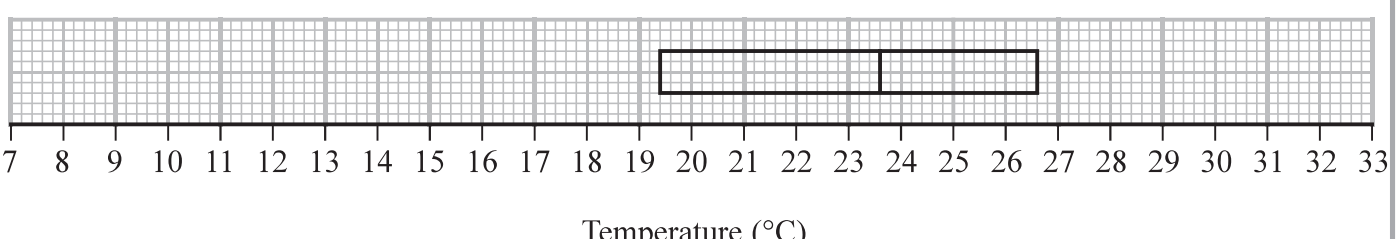
**Turn over for a spare grid if you need to redraw your box plot.**

**Question 2 continued**

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**Question 2 continued**

**Only use this grid if you need to redraw your box plot.**




**(Total for Question 2 is 11 marks)**

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**3.** Barbara is investigating the relationship between average income (GDP per capita), $x$ US dollars, and average annual carbon dioxide ($CO_2$) emissions, $y$ tonnes, for different countries.

She takes a random sample of 24 countries and finds the product moment correlation coefficient between average annual $CO_2$ emissions and average income to be 0.446

(a) Stating your hypotheses clearly, test, at the 5% level of significance, whether or not the product moment correlation coefficient for all countries is greater than zero.

**(3)**

Barbara believes that a non-linear model would be a better fit to the data.
She codes the data using the coding $m = \log_{10} x$ and $c = \log_{10} y$ and obtains the model $c = -1.82 + 0.89m$

The product moment correlation coefficient between $c$ and $m$ is found to be 0.882

(b) Explain how this value supports Barbara's belief.

**(1)**

(c) Show that the relationship between $y$ and $x$ can be written in the form $y = ax^n$ where $a$ and $n$ are constants to be found.

**(5)**

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**Question 3 continued**

**(Total for Question 3 is 9 marks)**

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**4.** Charlie is studying the time it takes members of his company to travel to the office. He stands by the door to the office from 08 40 to 08 50 one morning and asks workers, as they arrive, how long their journey was.

(a) State the sampling method Charlie used.

**(1)**

(b) State and briefly describe an alternative method of non-random sampling Charlie could have used to obtain a sample of 40 workers.

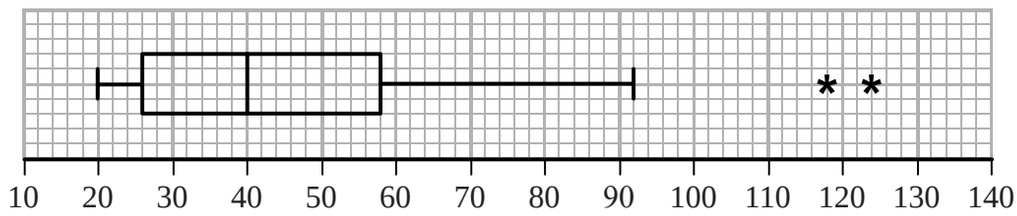
**(2)**

Taruni decided to ask every member of the company the time, $x$ minutes, it takes them to travel to the office.

(c) State the data selection process Taruni used.

**(1)**

Taruni's results are summarised by the box plot and summary statistics below.




Journey time (minutes)

$n = 95 \quad \sum x = 4133 \quad \sum x^2 = 202\,294$

(d) Write down the interquartile range for these data.

**(1)**

(e) Calculate the mean and the standard deviation for these data.

**(3)**

(f) State, giving a reason, whether you would recommend using the mean and standard deviation or the median and interquartile range to describe these data.

**(2)**

Rana and David both work for the company and have both moved house since Taruni collected her data.

Rana's journey to work has changed from 75 minutes to 35 minutes and David's journey to work has changed from 60 minutes to 33 minutes.

Taruni drew her box plot again and only had to change two values.

(g) Explain which two values Taruni must have changed and whether each of these values has increased or decreased.

**(3)**

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**Question 4 continued**

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