Quartiles, percentiles and measures of spread

97 marks

Hints online, answers free with an account: mathswariz.uk/worksheets/a-level-statistics-quartiles-percentiles-and-spread/

Date

A Do Now

Quick questions to start. Some use earlier lessons; some set a slip that the examiner reports say costs marks.

A1 Needed today [2 marks]

Find the median of these twelve values:
$23, 15, 31, 18, 27, 15, 40, 22, 19, 35, 26, 29$.

Answer .....

A2 Needed today [2 marks]

The frequencies of five classes, in order, are $5, 9, 14, 8, 4$. Write down the cumulative frequencies and state which class contains the 20th value.

Answer .....

A3 Common slip [2 marks]

For a data set, $Q_1 = 12$ and $Q_3 = 30$. Jo writes "the interquartile range is $12 < x < 30$". Write down the interquartile range correctly.

A4 Needed today [2 marks]

A class $20 \leqslant x < 30$ holds 10 values, and 14 values lie below 20. Assuming the values are spread evenly through the class, estimate the 19th value.

Answer .....

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PART 1 Quartiles of a list and of a frequency table

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EXAMPLE 1 · I DO

The numbers of customers in a shop in 15 one-hour periods are

$14,\ 26,\ 8,\ 12,\ 19,\ 3,\ 31,\ 15,\ 11,\ 21,\ 7,\ 18,\ 24,\ 12,\ 16$

Find the median, the quartiles, the interquartile range and the range.

Hint Order the data. For Q_1 work out $\frac{n}{4}$: if it is not a whole number, round up to find the position.

YOUR TURN · WE DO

B1 The masses, in grams, of 20 potatoes are

$52,\ 61,\ 64,\ 47,\ 85,\ 55,\ 50,\ 62,\ 58,\ 66,\ 49,\ 71,\ 53,\ 56,\ 46,\ 59,\ 68,\ 52,$

(a) Find the median and the quartiles. [3 marks]

Answer .....

(b) Find the interquartile range and the range. [2 marks]

Answer .....

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(c) Give a reason why the interquartile range is a better measure of spread than the range for these data. [2 marks]

EXAMPLE 2 · I DO

The numbers of cars, x, owned by 36 households are shown in the table. Find the quartiles and the interquartile range.

Cars, x	**0**	**1**	**2**	**3**	**4**
Frequency	5	12	10	6	3

Hint Add a row of cumulative frequencies. $\frac{36}{4} = 9$ is a whole number, so Q_1 is halfway between the 9th and 10th values.

YOUR TURN · WE DO

B2 The numbers of books, x, read last month by 35 students are shown in the table. Find the quartiles, the interquartile range and the range. [5 marks]

Books, x	**0**	**1**	**2**	**3**	**4**	**5**
Frequency	4	7	9	8	5	2

Answer .....

Total for B1: 7 marks

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C1 Here are 24 values in order: [4 marks]

$2,\ 3,\ 3,\ 4,\ 5,\ 5,\ 6,\ 7,\ 7,\ 8,\ 8,\ 9,\ 9,\ 10,\ 11,\ 11,\ 12,\ 12,\ 14,\ 14,\ 15,\ 16,\ 18,\ 20$

Ben takes the 6th and 18th values and says $Q_1 = 5$, $Q_3 = 12$. Explain his mistake and find the interquartile range correctly.

C2 The numbers of people, x, in 50 cars passing a checkpoint are shown in the table.

People, x	**1**	**2**	**3**	**4**	**5**
Frequency	18	14	9	6	3

(a) Find the quartiles and the interquartile range. [5 marks]

Answer .....

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(b) Two more cars pass, each with 5 people. Find the new quartiles, showing the positions you use. [4 marks]

Answer .....

Total for C2: 9 marks

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PART 2 Interpolation in grouped data

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EXAMPLE 3 · I DO

The times taken by 60 runners to finish a course, recorded to the nearest minute, are shown in the table. Estimate the median, the quartiles and the interquartile range.

Time (min)	Frequency
10–14	8
15–19	15
20–24	22
25–29	10
30–39	5

Hint Times to the nearest minute have class boundaries $9.5, 14.5, 19.5, \ldots$. For grouped data use the positions $\frac{n}{4}$, $\frac{n}{2}$ and $\frac{3n}{4}$.

YOUR TURN · WE DO

B3 The masses, m grams, of 80 eggs are shown in the table.

Mass, m (g)	Frequency
$40 \leq m < 50$	6
$50 \leq m < 55$	14
$55 \leq m < 60$	25
$60 \leq m < 65$	22
$65 \leq m < 80$	13

(a) Estimate the median mass. [3 marks]

Answer .....

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(b) Estimate the interquartile range. [4 marks]

PRACTICE · YOU DO

C3 The scores of 50 players, each a whole number, are grouped as 0–9: 4, 10–19: 10, 20–29: 16, 30–39: 12, 40–49: 8. Kim estimates the median as $20 + \frac{11}{16} \times 9 = 26.2$. Explain her mistake and estimate the median correctly. [4 marks]

Answer .....

~~Total for B3: 7 marks~~

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C4 The lengths, l cm, of 40 leaves are shown in the table. Ravi writes: "median $= 6 + \dfrac{20 - 16}{30} \times 2 = 6.27$ cm". Explain his mistake, then estimate the median and the upper quartile correctly. [5 marks]

Length, l (cm)	Frequency
$2 \leq l < 4$	5
$4 \leq l < 6$	11
$6 \leq l < 8$	14
$8 \leq l < 12$	10

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PART 3 Interpercentile ranges

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EXAMPLE 4 · I DO

The hours, h, that 100 students spend on homework in a week are shown in the table. (a) Estimate the 10th to 90th interpercentile range. (b) Estimate how many students spend more than 8 hours.

Hours, h	Frequency
$0 \leq h < 2$	9
$2 \leq h < 4$	21
$4 \leq h < 6$	30
$6 \leq h < 10$	28
$10 \leq h < 15$	12

Hint P_{10} is the $\frac{10}{100} \times 100 = 10$th value. For (b), take the part of the 6–10 class above 8, assuming its values are spread evenly.

YOUR TURN · WE DO

B4 The distances, d km, cycled in a week by 100 club members are shown in the table.

Distance, d (km)	Frequency
$0 \leq d < 5$	14
$5 \leq d < 10$	26
$10 \leq d < 20$	40
$20 \leq d < 30$	15
$30 \leq d < 50$	5

(a) Estimate the 20th to 80th interpercentile range. [4 marks]

Answer .....

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(b) Estimate how many members cycled between 8 km and 25 km. [3 marks]

PRACTICE · YOU DO

C5 The reaction times, t ms, of 60 people are shown in the table. Zara writes: "The 10th to 90th interpercentile range is $203 < t < 363$." Estimate the interpercentile range and write it correctly. [5 marks]

Time, t (ms)	Frequency
$150 \leq t < 200$	5
$200 \leq t < 250$	19
$250 \leq t < 300$	20
$300 \leq t < 400$	16

Answer .....

Total for B4: 7 marks

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C6 The times, t minutes, that 120 members spend at a gym on one visit are shown in the table.

Time, t (min)	Frequency
$0 \leq t < 30$	15
$30 \leq t < 45$	27
$45 \leq t < 60$	36
$60 \leq t < 90$	30
90 or more	12

(a) Explain why the range of the times cannot be found. [2 marks]

(b) Estimate the 10th to 90th interpercentile range. [3 marks]

Answer .....

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(c) Estimate how many members spent between 40 and 75 minutes at the gym. [3 marks]

Answer .....

Total for C6: 8 marks

D Exam-style questions

Edexcel exam style

D1 The lengths, t minutes, of 120 telephone calls to a help line are shown in the table.

Length, t (min)	Frequency
$0 \leq t < 2$	18
$2 \leq t < 5$	34
$5 \leq t < 10$	40
$10 \leq t < 20$	20
$20 \leq t < 40$	8

(a) Use linear interpolation to estimate the median. [3 marks]

Answer .....

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(b) Estimate the interquartile range. [4 marks]

Answer .....

(c) For calls to a second help line, the median is 7.2 minutes and the interquartile range is 4.1 minutes. Compare the lengths of calls to the two help lines. [3 marks]

Total for D1: 10 marks

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D2

A bank records the waiting times, w minutes, of 200 customers, shown in the table. An advert for the bank says: "Only 10% of our customers wait more than 15 minutes."

The advert is wrong.

Wait, w (min)	Frequency
$0 \leq w < 5$	46
$5 \leq w < 10$	72
$10 \leq w < 15$	50
$15 \leq w < 20$	20
$20 \leq w < 30$	12

(a) Estimate the 90th percentile of the waiting times. [3 marks]

Answer .....

(b) Estimate the 10th to 90th interpercentile range. [3 marks]

Answer .....

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(c) Explain why the advert is wrong. [3 marks]

Total for D2: 9 marks

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E Extension

Stretch

No route is given. The hints are at the end of the sheet. Use one at a time.

E1 The values of x for some observations are grouped in the table. Linear interpolation gives a lower quartile of 16 and a median of 24.5. The lower quartile lies in the class $10 \leqslant x < 20$ and the median in the class $20 \leqslant x < 30$. Find p and q. [9 marks]

Value, x	Frequency
$0 \leq x < 10$	6
$10 \leq x < 20$	p
$20 \leq x < 30$	q
$30 \leq x < 40$	12
$40 \leq x < 60$	7

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Extension hints

Cover these with paper. Uncover one at a time.

E1

Hint 1 The total number of observations is not given. Call it n and write it in terms of p and q.

Hint 2 Q_1 is the $\frac{n}{4}$th value. Interpolating in $10 \leqslant x < 20$ gives an equation linking n and p.

Hint 3 The median gives a second equation linking n, p and q. With $n = 25 + p + q$ you have three equations in three unknowns.

How did it go?

Colour one circle on each line: not yet, nearly, yes.

I can find the quartiles of raw data and of a frequency table using the n/4 rule.	○ ○ ○
I can use linear interpolation to estimate the median, quartiles and percentiles of grouped data.	○ ○ ○
I can find the range, interquartile range and interpercentile ranges, and estimate how many values lie in an interval.	○ ○ ○
I can choose a measure of spread and compare two distributions in context.	○ ○ ○

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