GCSE ONLINE TUTORING

STATISTICS / TOPIC GUIDE 58

58

Averages and measures of spread

Shared GCSE core with grouped-data estimates

Choose and calculate useful summaries rather than treating every average as interchangeable. Work from raw lists and frequency tables, estimate from grouped data, interpret quartiles and solve missing-value problems. Every comparison connects a typical value with variability and context.

Mean = Σfx / Σf • **IQR = Q3 − Q1**

Choose a useful centre and describe the spread.

UNDERSTAND THE IDEA. EXPLAIN THE METHOD.

Detailed teaching • Worked examples • Discussion • Original practice • Full solutions

Name: _____

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Before you begin

Add and divide accurately, order decimals, use negative numbers and read frequency tables.

Your route through this notebook

1. Mean, median and mode from a list
2. Averages from discrete frequency tables
3. Grouped data: estimating a mean and locating medians
4. Range, quartiles and interquartile range
5. Missing values, combined means and transformations

How to use it

Read a lesson, cover the worked solutions and try the examples yourself. Complete its practice page before checking the answers at the back. Finish with the mixed review, then return to any method you could not explain.

YOUR PROGRESS

After each lesson, ask: Can I explain the idea? Can I choose a method? Can I check my result? Record any questions you want to revisit.

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LESSON 1 / UNDERSTAND

Mean, median and mode from a list

The mean shares the total equally: mean = sum of values ÷ number of values. Use the number of observations, not the number of different values. Include repeated values and any zero or negative measurements. The mean uses every observation and changes when one extreme value changes. A typical value need not be one of the observed values.

The median is the middle value after ordering the data. For odd n, use position (n + 1)/2. For even n, average the values in positions n/2 and n/2 + 1. Positions identify observations, not their values. The mode is the most frequent value or category. A list can have more than one mode, or no unique most frequent value; state the situation clearly.

Choose an average to suit the purpose. The mode works for categorical data such as shoe colour, for which adding and dividing labels makes no sense. The median often resists the influence of an extreme numerical value. The mean remains useful when the total contribution matters. Explain your choice using the data and context, not a rule that one average is always best.

A reliable method

1. Count observations and order the list when finding the median.

2. Calculate the total/count, middle value(s), or highest frequency as required.

3. Interpret the result and check that a numerical average lies within the observed range.

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LESSON 1 / WORKED EXAMPLES

See the method in action

Try each example in the space provided before reading its solution. Explain why the method fits the question, not just which calculation to enter.

Worked example 1

Find the mean, median and mode of 2, 3, 3, 4, 13.

STEP-BY-STEP SOLUTION

Total 25 and n = 5, so mean 5. The ordered middle value is the third, 3; median 3. Value 3 occurs twice, more than any other, so mode 3. The high 13 pulls the mean above the median.

Worked example 2

Find the median and mean of −2, 0, 4, 6.

STEP-BY-STEP SOLUTION

The middle positions are 2 and 3: median (0 + 4)/2 = 2. Total 8 divided by 4 also gives mean 2. The two methods agree here, but they need not agree in general.

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LESSON 1 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

For 1, 2, 3, 4, the median is 2.5 even though 2.5 was not observed. This is valid. An “average” does not have to be an actual member of the list.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

1.1 Find all three averages for 1, 2, 2, 3, 7.

1.2 Find the median of 9, 2, 6, 3, 8, 4.

1.3 Which average can summarise the most popular eye colour? Explain.

1.4 A small group has one extremely high income. Which of mean or median is usually less affected by that extreme value?

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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LESSON 2 / UNDERSTAND

Averages from discrete frequency tables

A frequency table is a compressed list. If value x occurs f times, its contribution to the total is fx. Add these products and divide by the sum of frequencies: mean = Σfx/Σf. The symbol Σ means “sum of”. Do not average the value labels without using their frequencies; that would treat each distinct value as occurring equally often.

To find the median, work with observation positions in the expanded ordered list. Cumulative frequencies show where each value’s block ends. If frequencies for x = 0, 1, 2, 3 are 2, 5, 4, 1, cumulative frequencies are 2, 7, 11, 12. Positions 3–7 contain 1, so both central observations, positions 6 and 7, are 1. The mode is the x-value with highest f, not the frequency itself.

Keep the table headings clear. A column headed “number of siblings” gives values; a column headed “number of pupils” gives frequencies. The mean has units of the original variable. It may be fractional even if every observation is an integer count: an average of 1.5 siblings does not claim an individual has half a sibling.

A reliable method

1. Calculate Σf and each product fx, then add to get Σfx.

2. For the median, identify central positions using Σf and locate them cumulatively.

3. For the mode, report the value associated with the largest frequency.

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LESSON 2 / WORKED EXAMPLES

See the method in action

Try each example in the space provided before reading its solution. Explain why the method fits the question, not just which calculation to enter.

Worked example 1

For x = 0, 1, 2, 3 with frequencies 2, 5, 4, 1, find the mean.

STEP-BY-STEP SOLUTION

$\Sigma f = 12$. $\Sigma fx = 0\times2 + 1\times5 + 2\times4 + 3\times1 = 16$. Mean = 16/12 = 4/3 ≈ 1.33.

Worked example 2

For the same table, find median and mode.

STEP-BY-STEP SOLUTION

There are 12 observations. Positions 6 and 7 both lie in the block x = 1, since cumulative frequency reaches 7 at 1. Median 1. Highest frequency is 5 at x = 1, so mode 1.

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LESSON 2 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A frequency of 5 is not automatically the mode. If five pupils have one sibling, the mode of sibling count is 1, while 5 tells how often it occurs.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

2.1 Values 1, 2, 3 have frequencies 2, 3, 5. Find the mean.

2.2 For the same table, find the median.

2.3 For the same table, find the mode.

2.4 Values 0, 2, 4 have frequencies 3, 2, 1. Find the mean.

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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LESSON 3 / UNDERSTAND

Grouped data: estimating a mean and locating medians

Grouping removes exact individual values. For continuous classes, estimate the mean by representing every observation in a class by its midpoint: midpoint = (lower boundary + upper boundary)/2. Multiply midpoint m by frequency f, add mf and divide by total frequency. Label the result as an estimate. Exact frequencies do not make unknown within-class values exact.

For classes $0 \le t < 10$, $10 \le t < 20$ and $20 \le t < 30$, use midpoints 5, 15, 25. An estimated mean does not assume all actual observations were exactly at those midpoints; it substitutes representative values because the original measurements are unavailable. If values cluster near one end of a class, the approximation may be poor. Open-ended classes do not have a determined midpoint without extra assumptions.

Cumulative frequencies can locate a median class. With an even total, inspect both central observations, especially if they straddle a boundary. A table usually cannot give the exact median. The modal class is a class of highest frequency when comparing equal-width classes; for unequal-width histograms, the tallest bar instead has the greatest frequency density, as explained in guide 60.

A reliable method

1. Calculate class midpoints from boundaries, checking widths and units.

2. Form mf, sum the products and divide by Σf to estimate the mean.

3. Use cumulative counts for median positions and distinguish class information from exact values.

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LESSON 3 / WORKED EXAMPLES

See the method in action

Try each example in the space provided before reading its solution. Explain why the method fits the question, not just which calculation to enter.

Worked example 1

Times in minutes have classes [0, 10), [10, 20), [20, 30) and frequencies 4, 8, 8. Estimate the mean.

STEP-BY-STEP SOLUTION

Midpoints 5, 15, 25. Weighted total estimate $4\times5 + 8\times15 + 8\times25 = 340$ minutes. Divide by 20: estimated mean 17 minutes. Bracket [a, b) means a is included and b excluded.

Worked example 2

For the same table, identify the median class and modal class(es).

STEP-BY-STEP SOLUTION

There are 20 values; positions 10 and 11 both lie in the second class, because cumulative counts are 4, 12, 20. Median class $10 \le t < 20$. Frequencies 8 and 8 tie, so the second and third classes are joint modal classes.

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LESSON 3 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A mean calculated using midpoints is an estimate even if the final division is exact. The approximation comes from replacing unknown measurements, not from rounding the calculator answer.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

3.1 Estimate the mean for classes [0, 5), [5, 10), [10, 15) with frequencies 2, 6, 2.

3.2 For these data, identify the median class.

3.3 Explain why the exact mean cannot usually be recovered from a grouped table.

3.4 Why is a class “50 or more” problematic for a midpoint estimate?

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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LESSON 4 / UNDERSTAND

Range, quartiles and interquartile range

Spread describes how variable the data are. Range = maximum − minimum; it uses the two extremes and is sensitive to unusual values. Quartiles split ordered data into lower and upper sections. Q1 is the lower quartile, Q2 the median, and Q3 the upper quartile. Interquartile range, IQR = Q3 − Q1, describes the spread of the central part of the distribution and is less affected by isolated extremes than the range.

For small raw lists this guide uses the median-of-halves convention: order the data; when n is odd, exclude the overall median before finding the median of each half; when n is even, split into two equal halves. Other conventions and software can give different quartiles. If a question specifies a method, use it. On cumulative-frequency diagrams in guide 60, use the stated N/4, N/2 and 3N/4 reading positions instead.

Compare a typical value and a measure of spread together. A larger median means a higher central value, not necessarily “better”. A smaller IQR suggests the central values are more consistent, not that every observation is close or every value beats another group. Attach the comparison to the actual variable and units.

A reliable method

1. Order the values and calculate maximum − minimum.

2. Use the stated quartile convention to locate Q1 and Q3.

3. Calculate IQR and describe variability in context without claiming more than the summaries show.

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LESSON 4 / WORKED EXAMPLES

See the method in action

Try each example in the space provided before reading its solution. Explain why the method fits the question, not just which calculation to enter.

Worked example 1

Find range and IQR for 2, 4, 5, 7, 8, 10, 12, 15.

STEP-BY-STEP SOLUTION

Range 15 − 2 = 13. Lower half 2, 4, 5, 7 gives Q1 = 4.5. Upper half 8, 10, 12, 15 gives Q3 = 11. IQR = 11 − 4.5 = 6.5. Median is (7 + 8)/2 = 7.5.

Worked example 2

Find quartiles for 1, 3, 4, 6, 8, 9, 12 using this guide’s raw-list convention.

STEP-BY-STEP SOLUTION

Median 6 is excluded from the two halves. Lower half 1, 3, 4 gives Q1 = 3; upper half 8, 9, 12 gives Q3 = 9. IQR = 6. State this convention when comparing with a different calculation system.

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LESSON 4 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A dataset can have a small IQR and a very large range if one value is extreme. Neither summary alone tells the complete story.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

4.1 Find the range of $-4, -1, 3, 8$.

4.2 Find Q1, Q3 and IQR for 1, 2, 3, 4, 5, 6, 7, 8 using median-of-halves.

4.3 Journey times A have median 25 and IQR 4 minutes; B have median 28 and IQR 9. Compare.

4.4 Explain why the range alone can misrepresent the spread of most values.

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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LESSON 5 / UNDERSTAND

Missing values, combined means and transformations

Reverse a mean calculation by recovering the total: total = mean × number of observations. A missing value is the required total minus the total of known values. Check that the result is possible in context. If a stated mean was rounded, it may determine an interval rather than one exact total; assume exactness only when the question permits it.

To combine groups, add their totals and divide by the combined count. The ordinary average of group means works only when the group sizes are equal, unless an accidental special case produces the same result. The correct calculation weights each group mean by its size. Keep all observations in one unit before combining.

Adding a constant c to every value adds c to the mean, median and quartiles but leaves range and IQR unchanged. Multiplying every value by a positive factor k multiplies these summaries by k. Negative multipliers reverse order: do not apply positive-scale position reasoning blindly. For measurement conversions used here, scale factors are positive. Rounding individual values can also affect exact relationships.

A reliable method

1. Use n × mean to reconstruct each exact group total.

2. Add totals and counts separately, or subtract known values to isolate a missing one.

3. For a transformation, distinguish changes in location from changes in spread.

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LESSON 5 / WORKED EXAMPLES

See the method in action

Try each example in the space provided before reading its solution. Explain why the method fits the question, not just which calculation to enter.

Worked example 1

Five scores have exact mean 8. Four are 6, 7, 9, 10. Find the fifth.

STEP-BY-STEP SOLUTION

Required total $5 \times 8 = 40$. Known total 32. Missing score $40 - 32 = 8$. Check $(6 + 7 + 9 + 10 + 8)/5 = 8$.

Worked example 2

Ten values have mean 6 and thirty have mean 10. Find the combined mean.

STEP-BY-STEP SOLUTION

Totals $10 \times 6 = 60$ and $30 \times 10 = 300$. Combined mean $(60 + 300)/(10 + 30) = 360/40 = 9$. Averaging the means as 8 would give the smaller group too much weight.

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LESSON 5 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

If every temperature rises by 3°C, the typical temperatures rise but the spread does not. A change in level is different from a change in variability.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

5.1 Four numbers have exact mean 7. Three are 4, 6, 8. Find the fourth.

5.2 Combine 12 scores of mean 5 and 8 scores of mean 10.

5.3 All data have 5 added. What happens to the mean and IQR?

5.4 All lengths are multiplied by 100 to convert metres to centimetres. What happens to median and range?

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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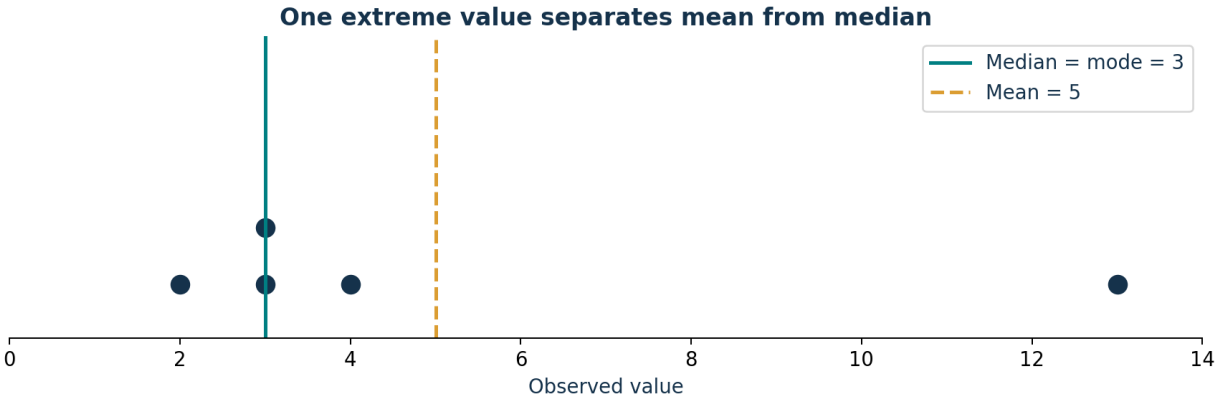
VISUAL EXPLAINER / READ DATA AND CHALLENGE THE MODEL

Read the model • 1



Frequency table: mean = Σfx/Σf = 16/12

Value x	Frequency f	Product fx
0	2	0
1	5	5
2	4	8
3	1	3
Total	12	16

WHAT THE REPRESENTATION SHOWS

Top: the observations are 2, 3, 3, 4, 13; repeated 3s are stacked. Total 25 divided by 5 gives mean 5, while the middle value and the mode are both 3. Bottom: a separate frequency-table dataset has total frequency 12 and weighted total 16, giving mean 4/3. Multiply values by their frequencies before adding.

Discuss: what does each axis or symbol represent? Identify the population, units and any assumptions. Recalculate one displayed result, then explain one conclusion the diagram cannot establish.

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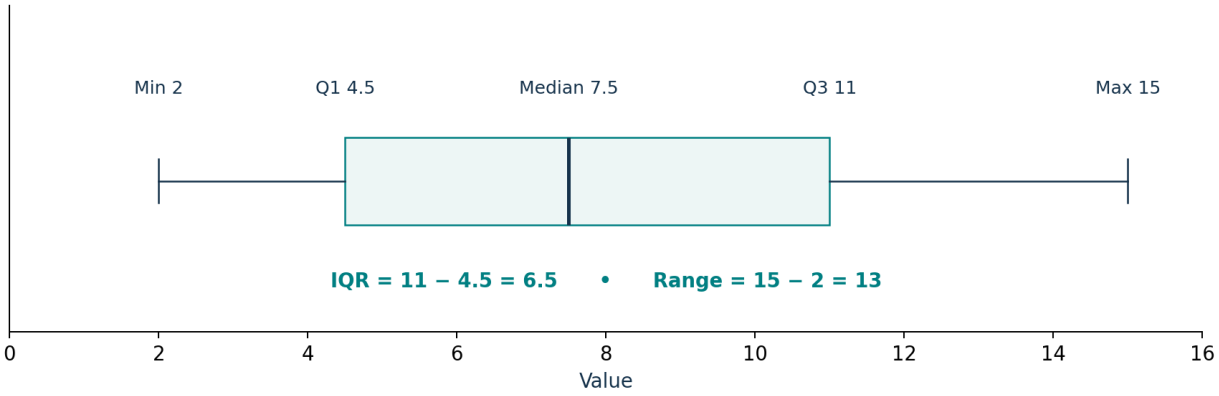
VISUAL EXPLAINER / READ DATA AND CHALLENGE THE MODEL

Read the model • 2

Raw list: 2, 4, 5, 7, 8, 10, 12, 15



Median-of-halves convention for this raw list



WHAT THE REPRESENTATION SHOWS

For eight ordered values, each half contains four observations. Q1 is the average of 4 and 5; Q3 is the average of 10 and 12. The box shows the IQR 6.5, while the complete whisker span shows the range 13. This basic plot uses whiskers at the minimum and maximum. The mean is not shown by a box plot.

Discuss: what does each axis or symbol represent? Identify the population, units and any assumptions. Recalculate one displayed result, then explain one conclusion the diagram cannot establish.

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MIXED REVIEW / ORIGINAL EXAM-STYLE PRACTICE

Apply your learning • 1

These questions are independently authored, not taken or adapted from past papers. Marks are suggested for self-assessment. Show your method and explain decisions. Use a calculator only where the arithmetic requires it.

R1. For 3, 4, 4, 7, 12 find the mean, median, mode and range. [4 marks]

R2. Values 1, 2, 3, 4 have frequencies 1, 3, 4, 2. Find the mean. [3 marks]

R3. For that table, find the median. [2 marks]

R4. Estimate the mean for classes [0, 10), [10, 20), [20, 30) with frequencies 2, 5, 3. [3 marks]

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MIXED REVIEW / ORIGINAL EXAM-STYLE PRACTICE

Apply your learning • 2

These questions are independently authored, not taken or adapted from past papers. Marks are suggested for self-assessment. Show your method and explain decisions. Use a calculator only where the arithmetic requires it.

R5. Using median-of-halves, find Q1, Q3 and IQR for 2, 3, 5, 6, 9, 10, 12, 13. [3 marks]

R6. Six values have exact mean 9. Five total 46. Find the sixth. [2 marks]

R7. A group of 15 has mean 12; a group of 5 has mean 20. Find the combined mean. [3 marks]

R8. A machine’s output has median 50 g and IQR 2 g; another has median 48 g and IQR 5 g. Compare without assuming a target mass. [2 marks]

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SOLUTIONS / LESSON PRACTICE

Check the reasoning

Your layout may differ. Compare the mathematical reasoning as well as the final answer. Correct any error, then reattempt the question without looking.

Lesson 1 • Mean, median and mode from a list

1.1 Find all three averages for 1, 2, 2, 3, 7.

Mean 15/5 = 3; median 2; mode 2.

1.2 Find the median of 9, 2, 6, 3, 8, 4.

Order 2, 3, 4, 6, 8, 9. Median (4 + 6)/2 = 5.

1.3 Which average can summarise the most popular eye colour? Explain.

The mode, because eye colour is categorical; a numerical mean or median of the labels is not meaningful.

1.4 A small group has one extremely high income. Which of mean or median is usually less affected by that extreme value?

Median, because its central position often stays unchanged while the total, and hence mean, increases.

Lesson 2 • Averages from discrete frequency tables

2.1 Values 1, 2, 3 have frequencies 2, 3, 5. Find the mean.

$\Sigma f = 10$; $\Sigma fx = 2 + 6 + 15 = 23$; mean 2.3.

2.2 For the same table, find the median.

Positions 5 and 6 are 2 and 3, respectively. Median (2 + 3)/2 = 2.5.

2.3 For the same table, find the mode.

3, because it has frequency 5, the largest frequency.

2.4 Values 0, 2, 4 have frequencies 3, 2, 1. Find the mean.

$\Sigma fx = 0 + 4 + 4 = 8$; $\Sigma f = 6$; mean 8/6 = 4/3.

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SOLUTIONS / LESSON PRACTICE

Check the reasoning • continued

Lesson 3 • Grouped data: estimating a mean and locating medians

3.1 Estimate the mean for classes [0, 5), [5, 10), [10, 15) with frequencies 2, 6, 2.

Midpoints 2.5, 7.5, 12.5; weighted total 5 + 45 + 25 = 75; total 10; estimated mean 7.5.

3.2 For these data, identify the median class.

Positions 5 and 6 lie in [5, 10), since cumulative counts are 2, 8, 10.

3.3 Explain why the exact mean cannot usually be recovered from a grouped table.

The values within each interval are unknown; different raw lists can give the same class frequencies but different totals.

3.4 Why is a class “50 or more” problematic for a midpoint estimate?

It has no specified upper boundary and hence no determined midpoint. Additional information or an explicitly justified assumption is needed.

Lesson 4 • Range, quartiles and interquartile range

4.1 Find the range of −4, −1, 3, 8.

8 − (−4) = 12.

4.2 Find Q1, Q3 and IQR for 1, 2, 3, 4, 5, 6, 7, 8 using median-of-halves.

Q1 = 2.5; Q3 = 6.5; IQR = 4.

4.3 Journey times A have median 25 and IQR 4 minutes; B have median 28 and IQR 9. Compare.

A has a lower typical journey time and less central variability. These summaries do not show that every A journey is faster than every B journey.

4.4 Explain why the range alone can misrepresent the spread of most values.

It depends only on the minimum and maximum; one extreme observation can make it large even when most observations are closely grouped.

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SOLUTIONS / LESSON PRACTICE

Check the reasoning • continued

Lesson 5 • Missing values, combined means and transformations

5.1 Four numbers have exact mean 7. Three are 4, 6, 8. Find the fourth.

Total 28; known total 18; missing value 10.

5.2 Combine 12 scores of mean 5 and 8 scores of mean 10.

Total 60 + 80 = 140; count 20; combined mean 7.

5.3 All data have 5 added. What happens to the mean and IQR?

Mean increases by 5; IQR stays the same because both quartiles increase by 5.

5.4 All lengths are multiplied by 100 to convert metres to centimetres. What happens to median and range?

Both numerical values are multiplied by 100, with units changing from metres to centimetres.

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SOLUTIONS / MIXED REVIEW

Answers and marking guidance

Award the suggested method marks for valid working, even where a later arithmetic slip occurs. Do not count the same step twice. These are independent teaching allocations, not official exam-board mark schemes.

R1. For 3, 4, 4, 7, 12 find the mean, median, mode and range. [4 marks]

Total 30 gives mean 6; median 4; mode 4; range 9. [1 each.]

R2. Values 1, 2, 3, 4 have frequencies 1, 3, 4, 2. Find the mean. [3 marks]

$\Sigma fx = 1 + 6 + 12 + 8 = 27$; $\Sigma f = 10$; mean 2.7. [1 products/total; 1 count; 1 result.]

R3. For that table, find the median. [2 marks]

Positions 5 and 6 both contain 3, because cumulative counts are 1, 4, 8, 10. Median 3. [1 positions; 1 result.]

R4. Estimate the mean for classes [0, 10), [10, 20), [20, 30) with frequencies 2, 5, 3. [3 marks]

Midpoints 5, 15, 25; total estimate 10 + 75 + 75 = 160; mean estimate 16. [1 midpoints; 1 weighted total; 1 division.]

R5. Using median-of-halves, find Q1, Q3 and IQR for 2, 3, 5, 6, 9, 10, 12, 13. [3 marks]

Q1 = (3 + 5)/2 = 4; Q3 = (10 + 12)/2 = 11; IQR 7. [1 each.]

R6. Six values have exact mean 9. Five total 46. Find the sixth. [2 marks]

Required total 54; missing value 8. [1 total; 1 subtraction.]

R7. A group of 15 has mean 12; a group of 5 has mean 20. Find the combined mean. [3 marks]

Totals 180 and 100; combined 280/20 = 14. [1 totals; 1 count; 1 result.]

R8. A machine’s output has median 50 g and IQR 2 g; another has median 48 g and IQR 5 g. Compare without assuming a target mass. [2 marks]

First machine has a higher median output mass and smaller central variability. Without a desired mass, higher is not automatically better. [1 location; 1 contextual spread.]

Reflect, repair and revisit

Record one secure method, one mistake you corrected and one question to retry. Reattempt the questions you missed in a few days. Explain why your new method works before you compare your answer.

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