GCSE ONLINE TUTORING

STATISTICS / TOPIC GUIDE 59

59

Charts, time series and scatter graphs

Shared GCSE core with interpretation and construction

Turn data into clear visual arguments. Construct and interpret bar charts, pictograms, pie charts and stem-and-leaf diagrams, then explore change over time and relationships between variables. Learn to challenge misleading scales and unsupported causal claims.

Sector angle = frequency / total × 360°

Read the scale; distinguish counts from proportions.

UNDERSTAND THE IDEA. EXPLAIN THE METHOD.

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

Name: _____

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Your learning guide

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Before you begin

Use percentages, angles, coordinates and averages. Have a ruler, protractor and separate squared paper for chart construction.

Your route through this notebook

1. Bar charts, pictograms and misleading displays
2. Pie charts and proportional comparison
3. Stem-and-leaf and back-to-back diagrams
4. Time series, trends and moving averages
5. Scatter graphs, lines of best fit and causation

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

Bar charts, pictograms and misleading displays

A bar chart displays categorical data or individual discrete values. Categories usually have separated equal-width bars; heights represent frequencies on a common numerical scale. Label both axes, include units where relevant and use a scale that can be read accurately. Do not join unrelated categories with a line, because the intermediate positions have no numerical meaning.

A pictogram uses a key to show how many observations one symbol represents. Fractional symbols must be read using that key, not counted as whole symbols. If a full symbol stands for 8 pupils, a half stands for 4 and a quarter for 2. Choose a sensible key before drawing and use symbols of consistent size.

Look critically at scales. Truncating a bar chart’s frequency axis can make a modest difference in counts appear enormous because lengths are normally interpreted from zero. A clearly marked axis break still requires careful explanation. Pictures enlarged in both height and width can exaggerate a numerical increase through area. Compare the actual numbers, not just visual impressions. A chart should also identify its population and period so that the frequencies mean something.

A reliable method

1. Identify categories or discrete values and count each frequency.

2. Choose and label an appropriate scale or pictogram key.

3. Check totals and evaluate whether the display fairly represents the numerical differences.

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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

Travel counts are walk 12, bus 18, cycle 6. Describe a suitable bar chart.

STEP-BY-STEP SOLUTION

Use three separated bars of equal width, labelled Walk, Bus and Cycle. Put frequency on a vertical axis starting at zero, for example in steps of 3. Heights are 12, 18 and 6; total 36 pupils.

Worked example 2

A pictogram key says one full symbol = 8 pupils. What do 2¾ symbols represent?

STEP-BY-STEP SOLUTION

Two full symbols give 16 and three quarters give 6, so total 22 pupils. Conversely 20 pupils require 20/8 = 2½ symbols.

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LESSON 1 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A bar of height 110 compared with one of height 100 shows a 10% increase. If both are drawn from a baseline of 95, their visible lengths have ratio 15:5, which can wrongly suggest a tripling.

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 Using the key one symbol = 6 books, interpret 3½ symbols.

1.2 For frequencies A:7, B:11, C:2, state the total and tallest bar.

1.3 A bar chart axis starts at 48 and shows values 50 and 60. Explain the danger.

1.4 On squared paper, construct a bar chart for red 8, blue 5, green 7.

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

Pie charts and proportional comparison

A pie chart divides one whole into sectors. Sector angle = category frequency ÷ total frequency × 360°. Use a protractor from a common centre; label categories and include a title or key. Angles should total 360°, allowing for stated rounding. A percentage p corresponds to 3.6p degrees. A right angle represents one quarter of the whole, not automatically 90 people.

To recover a frequency, multiply total × sector angle/360. This requires the total population represented. Without it, the chart gives proportions only. If the data are rounded, recovered frequencies can be approximate. Choose rounding that preserves a coherent complete circle; avoid accumulating a discrepancy without noticing.

Two equal-sized pie charts do not imply equal sample sizes. A 50% sector of 20 people is 10 people, while a 25% sector of 100 is 25 people. Compare proportions when describing shares, and use the actual totals when comparing counts. Pie charts work best with a small number of categories that form an exclusive and complete partition of one whole.

A reliable method

1. Add frequencies and calculate each category’s fraction of the total.
2. Convert fractions to angles or angles back to frequencies using the whole.
3. Check 360° and distinguish a larger proportion from a larger count.

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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

A survey of 40 has counts A:10, B:14, C:16. Find sector angles.

STEP-BY-STEP SOLUTION

Each response corresponds to 360/40 = 9°. Angles are 90°,126°,144°. They total 360°.

Worked example 2

A sector is 72° in a chart representing 150 pupils. How many pupils are in it?

STEP-BY-STEP SOLUTION

Fraction 72/360 = 1/5. Frequency 150/5 = 30 pupils. Without the total of 150, only the 20% share could be determined.

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LESSON 2 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

Pie charts for different years need their totals stated. A shrinking percentage can still correspond to a growing count if the overall population has grown enough.

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 Convert 35% to a pie-chart angle.

2.2 A category has 18 of 60 responses. Find its angle.

2.3 A 120° sector represents part of 90 items. Find the frequency.

2.4 Chart A shows 40% of 50 people; B shows 30% of 100. Which has more people in the category?

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

Stem-and-leaf and back-to-back diagrams

A stem-and-leaf diagram retains individual numerical values while showing their distribution. Choose a place-value split, write stems in order and put leaves in increasing order for a standard single-sided display. A key is essential: 2 | 7 = 27 minutes differs from 2 | 7 = 2.7 kg. Repeated observations require repeated leaves. Empty stems can help preserve the numerical scale.

To read a diagram, reconstruct observations using its key, count leaves and locate ordered positions for a median. A mode has repeated identical stem–leaf combinations. The leaves alone do not give the original values. For example, leaf 9 on stem 1 is 19, while leaf 1 on stem 3 is 31; leaf size cannot determine the overall maximum without its stem.

A back-to-back diagram shares stems for two groups. On the right, leaves usually increase outwards from the stem; on the left, they usually decrease from left to right so that the smallest is nearest the stem. Include a two-sided key. Compare centre and spread with the original units, and account for different sample sizes rather than simply comparing how full the rows look.

A reliable method

1. Choose stems and leaves appropriate to the data precision and state a key.
2. Sort stems and leaves, preserving repetitions and the total count.
3. Reconstruct values to calculate summaries or compare groups.

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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

Construct a stem-and-leaf diagram for 12, 17, 17, 23, 25, 31.

STEP-BY-STEP SOLUTION

Use stems 1, 2, 3. Rows: 1 | 2 7 7; 2 | 3 5; 3 | 1. Key 1 | 2 = 12. Six leaves represent all six values; 17 appears twice.

Worked example 2

For those values, find median and range.

STEP-BY-STEP SOLUTION

The ordered middle positions 3 and 4 are 17 and 23. Median 20; range 31 − 12 = 19. The mode is 17. Do not average the stems or leaves separately.

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LESSON 3 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A key supplies units and precision, not just decoration. The same digits can describe very different measurements under different keys.

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 Rows are 0 | 4 8 and 1 | 1 1 6, with key 1 | 6 = 16. List the data.

3.2 Find median and mode for that diagram.

3.3 Construct a diagram for 2.1, 2.4, 2.4, 3.0 with key stem | leaf = units | tenths.

3.4 Why must two observations of 17 produce two leaves on stem 1?

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

Time series, trends and moving averages

A time series records a variable at ordered times. Put time on the horizontal axis and the measured quantity, with units, on the vertical. Plot observations at their actual time positions. Joining successive points can help show change when time order has meaning, but it does not establish every unmeasured value between them. Distinguish the overall trend from short-term fluctuations.

Seasonal variation is a recurring pattern linked to a repeated calendar or operating cycle; it is not just any rise and fall. Compare corresponding seasons when a series is seasonal. A moving average smooths local variation by averaging overlapping windows. A three-point moving average of values at times 1, 2, 3 is placed at time 2; the next uses times 2, 3, 4 and is placed at time 3. A centred odd-width average loses values at both ends.

Forecasting extends a pattern beyond observed times and is uncertain. A trend may change, unusual events may occur, and seasonal behaviour may not repeat exactly. Use units and the observed period in any conclusion. A rising graph can show an association with time without explaining why the rise occurred.

A reliable method

1. Plot time and values on labelled, consistently spaced numerical axes.

2. Describe overall direction and any repeated cycle separately.

3. For a moving average, use the stated window, overlap it correctly and align with the middle time.

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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

Monthly sales for months 1–5 are 10, 14, 12, 18, 16. Find three-point moving averages.

STEP-BY-STEP SOLUTION

Months 1–3 average (10 + 14 + 12)/3 = 12, plotted at month 2. Months 2–4 average 44/3 ≈ 14.67 at month 3. Months 3–5 average 46/3 ≈ 15.33 at month 4. No centred three-point values exist at months 1 or 5.

Worked example 2

A shop has higher sales every December across several years. Describe the feature and a forecast limitation.

STEP-BY-STEP SOLUTION

This suggests a recurring seasonal peak, alongside any longer-term trend. A future December may differ because conditions can change; repetition in the historical data does not guarantee the next value.

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LESSON 4 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

Choosing a longer smoothing window can conceal short-term features. A moving average is a summary of nearby observations, not an additional measured observation.

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 three-point moving average of 8, 12, 16 and say where it is plotted.

4.2 For 4, 8, 6, 10, 12 find all three-point moving averages.

4.3 Explain the difference between trend and seasonality.

4.4 Why is extending a rising time-series line five years beyond the data risky?

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

Scatter graphs, lines of best fit and causation

A scatter graph displays paired measurements for the same individuals or cases. Plot each pair (x, y) at its numerical coordinates without joining points in sequence. Positive correlation means larger x tends to accompany larger y; negative correlation means larger x tends to accompany smaller y. No apparent linear correlation means no clear straight-line tendency, not proof that the variables are unrelated in every possible way.

A line of best fit describes the general linear tendency. Draw through the centre of the point cloud with roughly balanced scatter above and below; it need not pass through the origin or through particular observations. Use it to estimate y from x by moving to the line and across to the y-axis. An unusual point deserves investigation, not automatic deletion. The line’s equation, if given, can calculate the same model estimate.

Interpolation estimates within the observed x-range; extrapolation goes beyond it and is generally less secure because the pattern may not continue. Correlation does not establish causation: a third factor, reverse influence or selection may explain the association. A graph showing more umbrellas on wetter days does not show that umbrellas cause rain.

A reliable method

1. Identify the paired variables and plot each pair on labelled numerical axes.

2. Describe direction and strength of the visible tendency, noting unusual points.

3. Use a suitable fit for estimates and distinguish interpolation, extrapolation and causal claims.

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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

Data cover $1 \leq x \leq 6$ and a fitted line is $y = 2x + 3$. Estimate y at $x = 4$ and $x = 9$.

STEP-BY-STEP SOLUTION

At $x = 4$, $y = 11$: interpolation within the observed range. At $x = 9$, $y = 21$: extrapolation beyond it, so the estimate relies on an untested continuation of the line.

Worked example 2

A scatter graph shows positive correlation between ice-cream sales and suncream sales. Must one cause the other?

STEP-BY-STEP SOLUTION

No. Warm or sunny weather could increase both. The association is consistent with a common factor, and the graph alone cannot isolate a causal effect.

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LESSON 5 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A strong negative correlation is still strong: “negative” describes direction, not quality or weakness. Avoid calling a relationship strong merely because the points have large coordinates.

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 As journey distance increases, fuel used tends to increase. Name the likely correlation.

5.2 A fitted line is $y = 30 - 2x$. Estimate y at $x = 7$.

5.3 Observed x-values range from 10 to 30. Is an estimate at $x = 40$ interpolation or extrapolation?

5.4 Why should a best-fit line not automatically pass through (0, 0)?

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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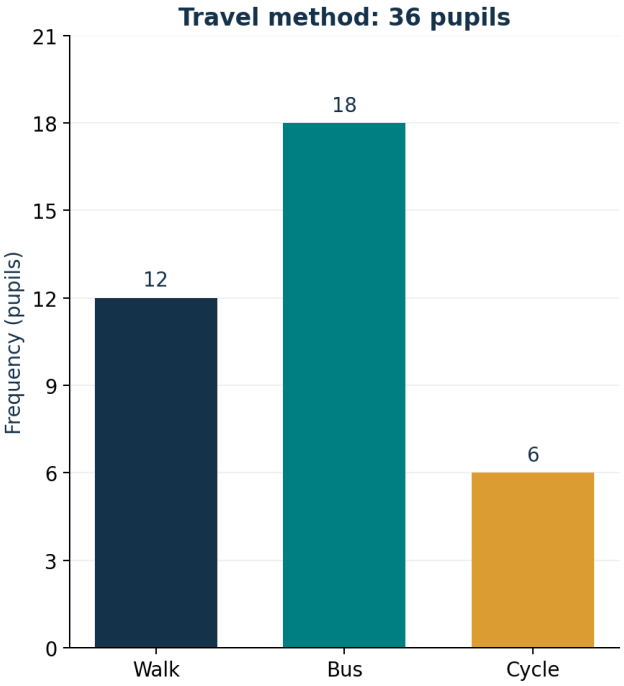
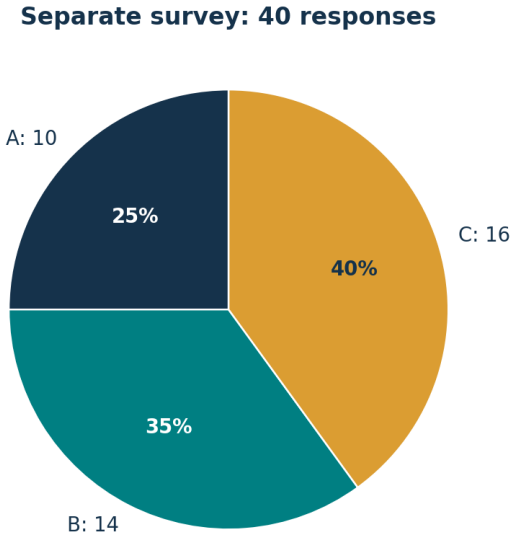
VISUAL EXPLAINER / READ DATA AND CHALLENGE THE MODEL

Read the model • 1





WHAT THE REPRESENTATION SHOWS

Left: separated equal-width bars show categorical travel counts 12, 18, 6 on a zero-based frequency axis. Right: a different survey has counts 10, 14, 16, hence shares 25%, 35%, 40% and sector angles 90°,126°,144°. A frequency axis uses counts; pie sectors use shares of a stated whole. Do not assume the two panels describe the same people.

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

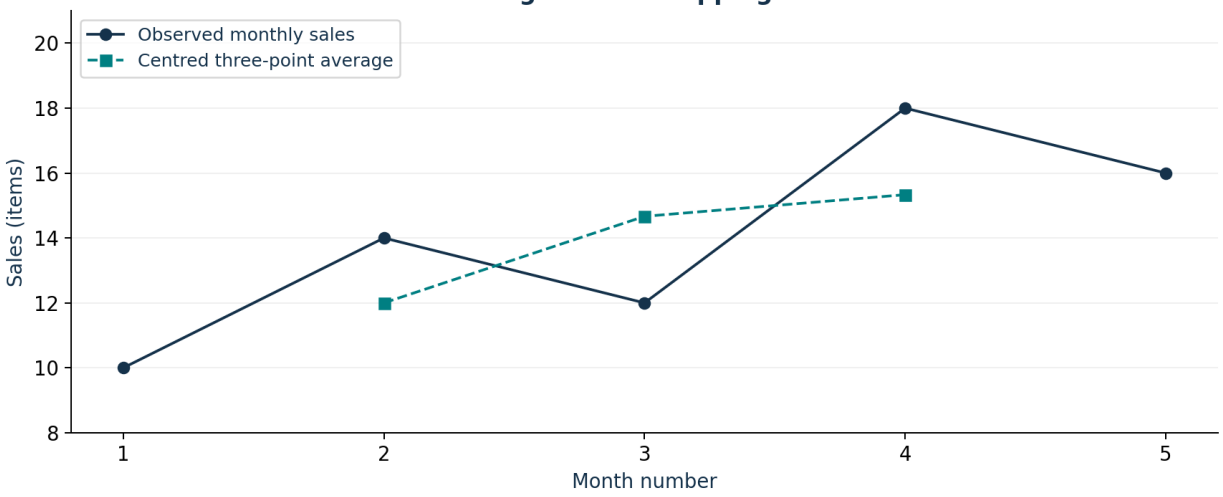
Read the model • 2

Stem-and-leaf keeps individual observations

Stem		Leaves
1	|	2 7 7
2	|	3 5
3	|	1

Key: 1 | 2 = 12
Data: 12,17,17,23,25,31
Median = 20

Smoothing uses overlapping windows



WHAT THE REPRESENTATION SHOWS

Top: every leaf is one observation; repeated 17 requires two leaves. The key gives place value. Bottom: monthly sales 10, 14, 12, 18, 16 have three-point averages 12, 14.67, 15.33, centred at months 2, 3, 4. The dashed smoothing line contains calculated summaries, not extra observed sales. Its endpoints cannot extend to months 1 or 5 with this centred window.

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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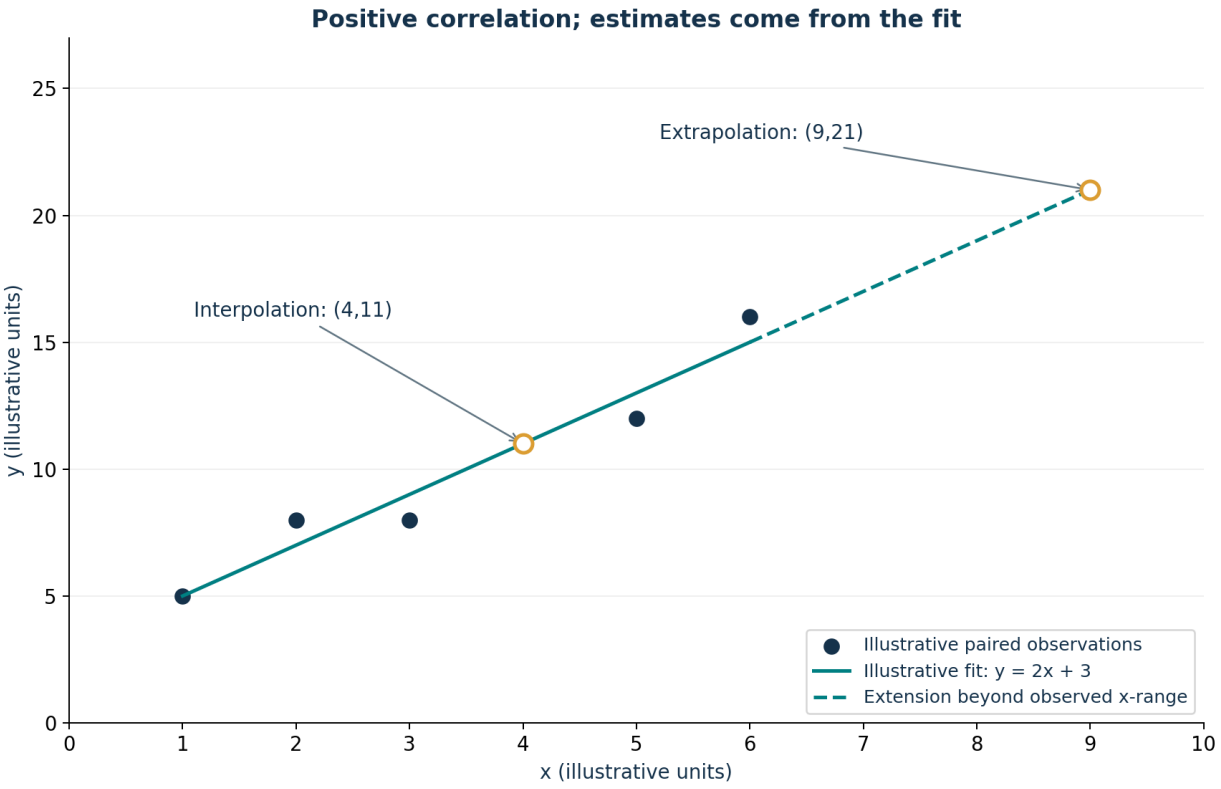
VISUAL EXPLAINER / READ DATA AND CHALLENGE THE MODEL

Read the model • 3



WHAT THE REPRESENTATION SHOWS

The measured x-values run from 1 to 6. The supplied teaching fit y = 2x + 3 estimates y = 11 at x = 4, inside the data range, and y = 21 at x = 9, beyond it. These are line estimates, not measured observations. The broken extension makes the extra assumption visible. A positive association alone does not establish causation.

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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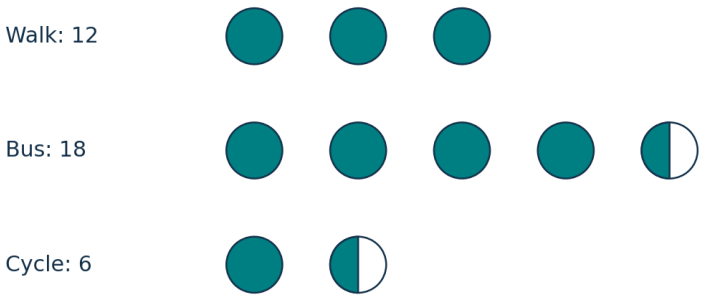
VISUAL EXPLAINER / READ DATA AND CHALLENGE THE MODEL

Read the model • 4

Pictogram key: one full circle = 4 pupils



Back-to-back stem-and-leaf: two separate groups

Group A	Stem	Group B
7 7 2	1	4 8
5 3	2	1 1 7
1	3	2

Key: 7 | 1 | 4 means 17 in A and 14 in B

WHAT THE REPRESENTATION SHOWS

Top: each full circle represents four pupils, so a half-circle represents two. The travel counts are 12, 18, 6. Bottom: A has values 12, 17, 17, 23, 25, 31; B has 14, 18, 21, 21, 27, 32. Left-side leaves increase towards the outside when read from the stem, so the written left row is in descending order from left to right. The key applies place value on both sides. Medians are 20 and 21; ranges are 19 and 18. These are two distinct datasets from the travel pictogram.

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. A pictogram uses one symbol for 12 people. Interpret 2¼ symbols. [2 marks]

R2. A pie chart represents 80 responses. Find the angle for 18 responses. [2 marks]

R3. A 150° sector represents 50 people. Find the whole population. [3 marks]

R4. Construct a stem-and-leaf diagram for 14, 18, 21, 21, 27, 32 and state a key. [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. Find median and range of those six observations. [2 marks]

R6. Four equally spaced observations are 6, 9, 12, 15. Calculate three-point moving averages and state their positions. [3 marks]

R7. An observed x-range is 2–8. A fitted line is $y = 4x + 5$. Estimate at $x = 6$ and explain why an estimate at $x = 12$ is less secure. [3 marks]

R8. Two charts show 25% of 200 and 40% of 100 in a category. Compare counts and shares. [3 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 • Bar charts, pictograms and misleading displays

1.1 Using the key one symbol = 6 books, interpret 3½ symbols.

3.5 × 6 = 21 books.

1.2 For frequencies A:7, B:11, C:2, state the total and tallest bar.

Total 20; category B has the tallest bar, with frequency 11.

1.3 A bar chart axis starts at 48 and shows values 50 and 60. Explain the danger.

Visible bar lengths 2 and 12 can exaggerate the difference. The actual value ratio is 60/50 = 1.2, not 6.

1.4 On squared paper, construct a bar chart for red 8, blue 5, green 7.

Use separated equal-width bars, labelled categories, a frequency axis from zero and heights 8, 5, 7. Check total 20. A sensible scale reaches at least 8.

Lesson 2 • Pie charts and proportional comparison

2.1 Convert 35% to a pie-chart angle.

0.35 × 360 = 126°.

2.2 A category has 18 of 60 responses. Find its angle.

18/60 × 360 = 108°.

2.3 A 120° sector represents part of 90 items. Find the frequency.

120/360 × 90 = 30.

2.4 Chart A shows 40% of 50 people; B shows 30% of 100. Which has more people in the category?

A has 20 and B has 30. B has more people despite its smaller proportion.

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SOLUTIONS / LESSON PRACTICE

Check the reasoning • continued

Lesson 3 • Stem-and-leaf and back-to-back diagrams

3.1 Rows are 0 | 4 8 and 1 | 1 1 6, with key 1 | 6 = 16. List the data.

4, 8, 11, 11, 16.

3.2 Find median and mode for that diagram.

Median 11; mode 11.

3.3 Construct a diagram for 2.1, 2.4, 2.4, 3.0 with key stem | leaf = units | tenths.

2 | 1 4 4; 3 | 0. Key 2 | 1 = 2.1.

3.4 Why must two observations of 17 produce two leaves on stem 1?

Each leaf represents one observation. Removing a repeated leaf changes the sample size and its frequency distribution.

Lesson 4 • Time series, trends and moving averages

4.1 Find the three-point moving average of 8, 12, 16 and say where it is plotted.

12, plotted at the middle time of those three observations.

4.2 For 4, 8, 6, 10, 12 find all three-point moving averages.

6, 8, 28/3 ≈ 9.33, at the second, third and fourth times respectively.

4.3 Explain the difference between trend and seasonality.

Trend is longer-term direction; seasonality is a recurring pattern associated with a repeating time cycle.

4.4 Why is extending a rising time-series line five years beyond the data risky?

It assumes the historical pattern continues over a period where conditions may change. The further extension is unsupported by observed values.

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SOLUTIONS / LESSON PRACTICE

Check the reasoning • continued

Lesson 5 • Scatter graphs, lines of best fit and causation

5.1 As journey distance increases, fuel used tends to increase. Name the likely correlation.

Positive correlation.

5.2 A fitted line is $y = 30 - 2x$. Estimate y at $x = 7$.

$30 - 14 = 16$, in the units of y.

5.3 Observed x-values range from 10 to 30. Is an estimate at $x = 40$ interpolation or extrapolation?

Extrapolation; 40 is outside the observed x-range.

5.4 Why should a best-fit line not automatically pass through (0, 0)?

The data may support a non-zero intercept and may not include $x = 0$. Forcing the origin can misrepresent the observed tendency.

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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. A pictogram uses one symbol for 12 people. Interpret 2¼ symbols. [2 marks]

2.25 × 12 = 27 people. [1 correct fractional symbol; 1 result.]

R2. A pie chart represents 80 responses. Find the angle for 18 responses. [2 marks]

18/80 × 360 = 81°. [1 proportional method; 1 angle.]

R3. A 150° sector represents 50 people. Find the whole population. [3 marks]

50 is 150/360 of the whole, so total 50 × 360/150 = 120. [1 fraction relationship; 1 rearrangement; 1 total.]

R4. Construct a stem-and-leaf diagram for 14, 18, 21, 21, 27, 32 and state a key. [3 marks]

1 | 4 8; 2 | 1 1 7; 3 | 2. Key 1 | 4 = 14. [1 stems; 1 ordered complete leaves; 1 key.]

R5. Find median and range of those six observations. [2 marks]

Median (21 + 21)/2 = 21; range 32 − 14 = 18. [1 each.]

R6. Four equally spaced observations are 6, 9, 12, 15. Calculate three-point moving averages and state their positions. [3 marks]

Averages 9 and 12, plotted at times 2 and 3. [1 each value; 1 alignment.]

R7. An observed x-range is 2–8. A fitted line is y = 4x + 5. Estimate at x = 6 and explain why an estimate at x = 12 is less secure. [3 marks]

At 6, y = 29. At 12 the method extrapolates beyond the observed range and assumes the same relation continues. [1 estimate; 1 extrapolation; 1 assumption.]

R8. Two charts show 25% of 200 and 40% of 100 in a category. Compare counts and shares. [3 marks]

First count 50 versus second 40, so the first has more people. The second has the larger share, 40% versus 25%. [1 counts; 1 count comparison; 1 share comparison.]

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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