

Science 7–8

Chapter 4 — Processing, modelling and analysing

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Organising data: table conventions, choosing and constructing the right graph, and processing with spreadsheet formulas

What we teach here — VC2S8I04 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“data and information can be organised and processed by selecting and constructing representations including tables, graphs, keys, models and mathematical relationships” **This subtopic owns the tables-**

and-graphs clause only: selecting and constructing tables and graphs to organise and process data and information. The rest of the CD — keys, models and mathematical relationships — belongs to the partner subtopic **4B** († split delivery, D6). **In our words:** measurements on their own are just numbers scattered

across a page. A table tidies them so anyone can read them, a graph turns them into a shape you can see, and a spreadsheet does the repeated number-work so you can think about what the numbers mean. This subtopic is the craft of turning measurements into meaning: build a table someone else can read without asking you a single question, choose the display that answers the question your data is asking, construct that display well, and let simple spreadsheet formulas do the processing. **Achievement-standard extract served here (D13):** “*They select and construct appropriate representations to organise and process data and information.*” 4A is the owner of VC2S8I04, so the extract appears here in full; the partner subtopic 4B cites it by reference to this header. **Elaborations drawn on:** VC2S8I04 .E06 (using simple formulas

in spreadsheets to organise and process generated or collected data) — a thin bank, authored from the CD text (D12). The spreadsheet strand of this subtopic is E06; the tables and graphs strands are authored from the CD text itself together with the Maths interlock below. **Maths interlock (D11):** rounding and estimating (VC2M7N04) sets the rule for reporting a calculated mean; range, median, mean and mode (VC2M7ST01) are the processing words used with our class data set; dot plots and stem-and-leaf plots (VC2M7ST02) are the displays used for spread; plotting from a table of values (VC2M7A05) is practised in the line-graph build; and reading and interpreting graphs (VC2M7A04) is practised in the fault-finding and finding-sentence tasks. **Scope notes:** the ceiling is held. Points on a line graph are joined dot to dot and the shape of a graph is described in words only — gradient (VC2M9A04) and lines of best fit with scatterplots (graphs in which each pair of measurements is plotted as its own separate, unjoined point; VC2M10ST02) are later learning and are not taught here. Scientific notation (VC2M9M02) is not used. Keys, models and mathematical relationships are 4B’s.

Word watch — *data, information, representation, category, outlier*. **Data** are the measurements and facts you collect — the numbers written down during a practical, before anything has been done to them.

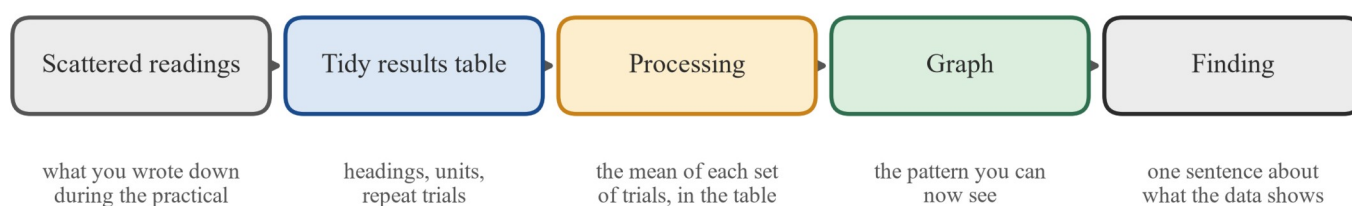
Information is data that has been organised so it tells you something — data with a shape and a message. A **representation** is a way of showing data: a table, a graph, a diagram. The curriculum’s CD uses the word for exactly this family of displays. A **category** is a named group — a surface, a colour, a brand — as opposed to a measured number. And an **outlier** is a value that sits a long way from the others in a data set; it is the point that makes you look twice before you trust it.

Theory

From measurements to meaning

Every practical ends the same way: a page of numbers written down as fast as you could read them. Those numbers are **data**. Left as they are, they tell nobody anything. The job after a practical is to turn data into **information** — and that job has a shape. This subtopic walks the whole pipe, one step at a time.

From measurements to meaning: the organising pipeline



Each step turns the data into something the next step can use — and the whole pipeline turns measurements into meaning.

Flow chart titled “From measurements to meaning: the organising pipeline”, with five boxes joined by arrows left to right: “Scattered readings — what you wrote down during the practical”, then “Tidy results table — headings, units, repeat trials”, then “Processing — the mean of each set of trials, in the table”, then “Graph — the pattern you can now see”, then “Finding — one sentence about what the data shows”, with the caption “Each step turns the data into something the next step can use — and the whole pipeline turns measurements into meaning.”

Each step exists because the next step needs it. A graph built from scattered notes carries the mistakes of the notes into the picture. A finding read off a badly built graph is a finding about the mistakes, not about the science. So the pipeline is done in order, and each step is done well. That is the whole craft.

The tidy results table

Here is the same bounce investigation twice: once as it was written during the practical, once as a tidy results table. The numbers are identical — only the organising differs.

Raw notes — during the practical

<i>bounce ball — drop 20: 11.4 10.8 11.6</i>
<i>40 → 22.5 , 21.9 22.8</i>
<i>60? 33.6 / 32.8 + 34.0</i>
<i>80: 44.2 ... 43.6 ... 44.8</i>
<i>100 → 55.0 54.4 55.8</i>
<i>units?? cm i think</i>
<i>2nd try @ 80 hit table edge —</i>
<i>redid it, 44.8 is the good one</i>

Tidy results table — after the practical

Drop height (cm)	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)
20.0	11.4	10.8	11.6
40.0	22.5	21.9	22.8
60.0	33.6	32.8	34.0
80.0	44.2	43.6	44.8
100.0	55.0	54.4	55.8

same numbers — organised

simulated data for practice

Two panels. Left: a page of hurried raw notes — “bounce ball — drop 20: 11.4 10.8 11.6”, “40 → 22.5, 21.9 22.8”, “60? 33.6 / 32.8 + 34.0”, “80: 44.2 ... 43.6 ... 44.8”, “100 → 55.0 54.4 55.8”, “units?? cm i think”, “2nd try @ 80 hit table edge — redid it, 44.8 is the good one”. Right: a tidy results table titled with column headings “Drop height

(cm)”, “Trial 1 (cm)”, “Trial 2 (cm)”, “Trial 3 (cm)” and five rows of values, 20.0 to 100.0, with the caption “same numbers — organised”, labelled “simulated data for practice”.

The raw notes are honest and they are useless to anyone but the writer. Was the second 80 reading 43.6 or 44.8? The notes say the 43.6 trial hit the table edge and was redone — but you only learn that by reading the whole page. The tidy table makes six promises, and every results table in this book keeps them:

simulated data for practice

Table A Bounce height of a tennis ball at five drop heights
Title: what the table shows

Each heading names the quantity and its unit — once, not in every cell

Drop height (cm)	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	Mean bounce height (cm)
20.0	11.4	10.8	11.6	11.3
40.0	22.5	21.9	22.8	22.4
60.0	33.6	32.8	34.0	33.5
80.0	44.2	43.6	44.8	44.2
100.0	55.0	54.4	55.8	55.1

A processed column: the mean of the three trials

The variable you set (the independent variable) goes in the first column

Every reading to the same number of decimal places — the instrument's precision (here, 0.1 cm)

Results table with numbered notes for the bounce investigation, “Table A — Bounce height of a tennis ball dropped from different heights (simulated data for practice)”, with columns “Drop height (cm)”, “Trial 1 (cm)”, “Trial 2 (cm)”, “Trial 3 (cm)” and “Mean bounce height (cm)” and rows 20.0 to 100.0, with five numbered callouts: 1 a title that says what the table shows; 2 column headings that name the quantity and carry the unit once, not in every cell; 3 the thing you change in the first column, in order; 4 every reading to the same decimal place, 0.1 cm; 5 a processed column, the mean of each row’s trials, added to the table, not scribbled somewhere else.

1. **A title** says what the table shows — whose bounce, which ball, which surfaces or heights.
2. **Every column heading names its quantity and carries its unit once**, in the heading. The unit sits in “(cm)”, not in every cell — cells hold plain numbers.
3. **The thing you chose goes in the first column**, in order. Drop height is what the investigator set (20.0, 40.0, 60.0, 80.0, 100.0), so it leads, and the trials follow it.
4. **Every reading is written to the same number of decimal places** — here, one, because the ruler was read to 0.1 cm. Writing 55.0 rather than 55 says “this was measured to a tenth”.
5. **Processed numbers live in their own column**, clearly headed. The mean of each row’s three trials is part of the table, not a scribble in the margin.
6. **No commas inside numbers, and no skipped trials**. If a trial went wrong, the table shows the redone reading — the 43.6 that hit the table edge never entered Table A.

House rules for this book follow the same promises: values and units are separated by a space (“11.3 cm”, never “11.3cm”), and data tables carry no thousands commas.

Try it 1 — tidy the cooling notes (VC2S8I04)

A student measured the temperature of a cup of hot water every 2 minutes as it cooled. Their notes read:

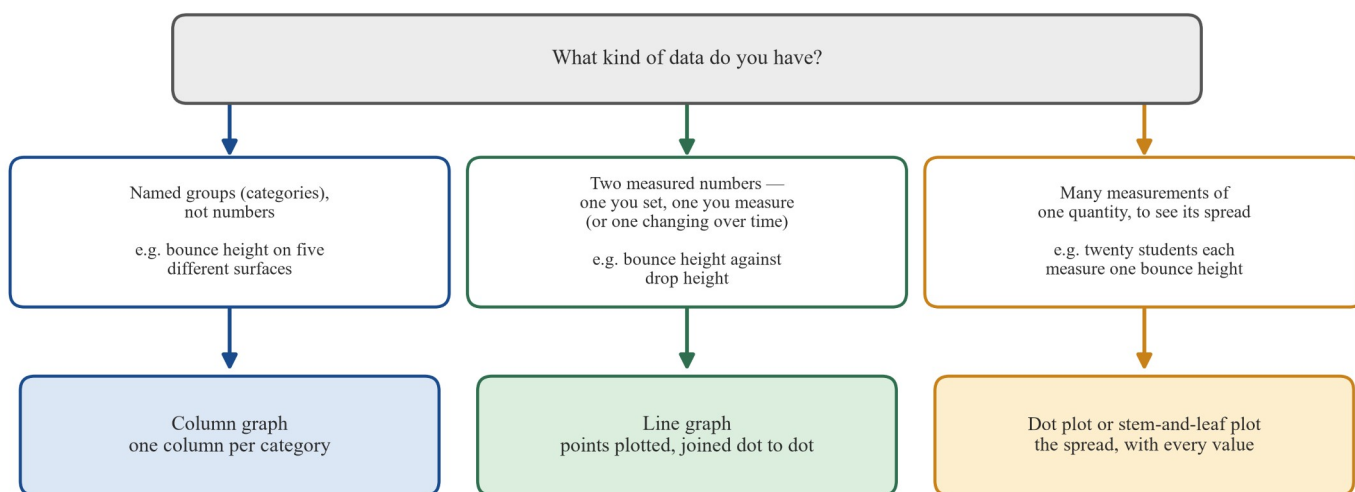
0 min → 78 · 2 min 65 · 4 min?? 55 · 6 → 47 · 8: 41 · 10 min 36 · degrees C

Write a tidy results table for these notes, keeping the six promises above. You will need a title, two column headings with the unit in the heading, and six rows in order. (There was one trial at each time, so there are no repeat trials to sort out here.)

Choosing the right display

A table keeps every exact value. A graph shows a shape. Different displays answer different questions, and the choice is made by asking one thing: *what kind of data do you have?*

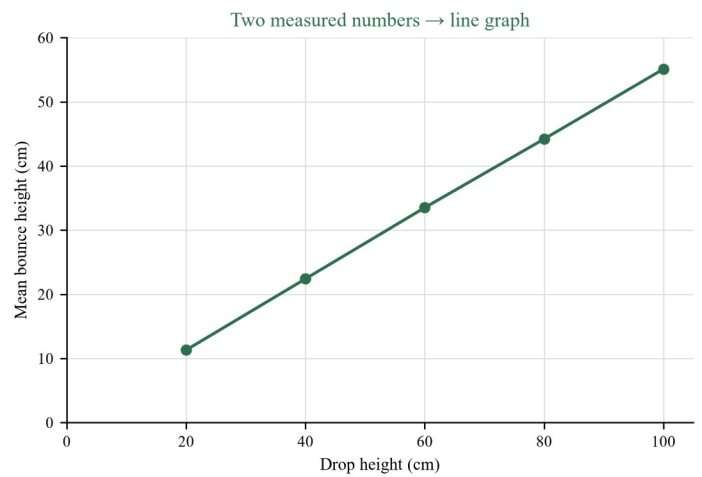
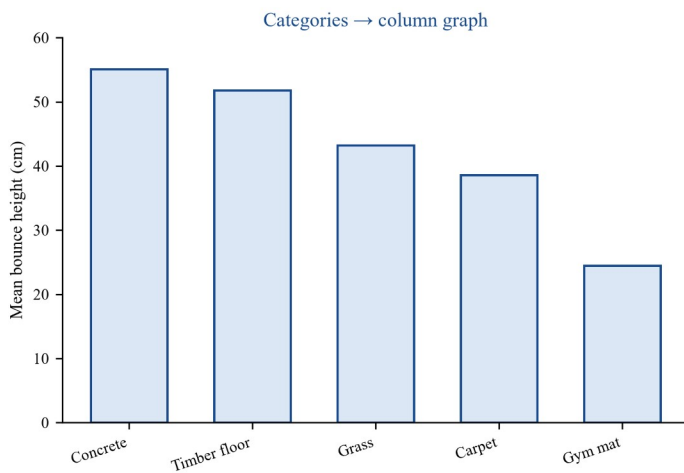
Choosing a display: what question is the data answering?



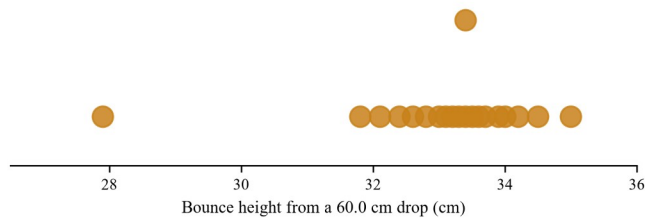
And when you need the exact values themselves, a table beats any graph — keep both.

Decision flow chart titled “Choosing a display: what question is the data answering?” From the top box “What kind of data do you have?”, three branches lead down. Left branch, blue: “Named groups (categories), not numbers — e.g. bounce height on five different surfaces” leading to “Column graph — one column per category”. Middle branch, green: “Two measured numbers — one you set, one you measure (or one changing over time) — e.g. bounce height against drop height” leading to “Line graph — points plotted, joined dot to dot”. Right branch, amber: “Many measurements of one quantity, to see its spread — e.g. twenty students each measure one bounce height” leading to “Dot plot or stem-and-leaf plot — the spread, with every value”. Caption: “And when you need the exact values themselves, a table beats any graph — keep both.”

The same investigation can be shown several ways, and each way does a different job. Here is the bounce investigation in four displays: the surfaces as a column graph, the drop-against-bounce numbers as a line graph, and the twenty single class measurements as a dot plot and as a stem-and-leaf plot.



Spread of one quantity → dot plot



...and a stem-and-leaf plot keeps every value

Stem	Leaf
27	9
31	8
32	1 4 6 8
33	0 1 2 3 4 4 5 6 7 9
34	0 2 5
35	0

Key: 33 | 4 means 33.4 cm

Four displays, four jobs — same bounce investigation, simulated data for practice

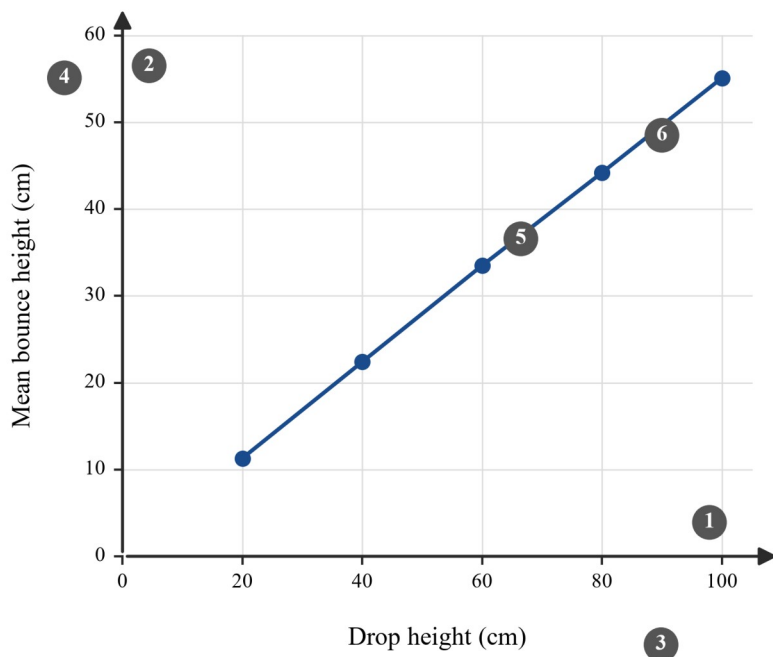
Four panels showing the same bounce investigation four ways. Top left: a column graph of mean bounce height (cm) for five surfaces — Concrete 55.1, Timber floor 51.8, Grass 43.2, Carpet 38.6, Gym mat 24.5 — one separated column per category. Top right: a line graph of mean bounce height (cm) against drop height (cm), points at (20, 11.3), (40, 22.4), (60, 33.5), (80, 44.2), (100, 55.1) joined dot to dot and rising steadily. Bottom left: a dot plot of twenty single bounce heights from a 60.0 cm drop, most dots clustered between 31.8 and 35.0 with one dot far away at 27.9. Bottom right: a stem-and-leaf plot of the same twenty values with key “33 | 4 means 33.4 cm”, captioned “Four displays, four jobs — same bounce investigation, simulated data for practice”.

The column graph answers *which group, and how do the groups compare?* The line graph answers *how does one measured number change as the other changes?* The dot plot and the stem-and-leaf plot answer *how spread out are the values, and is anything unusual in there?* And the table underneath them all keeps the exact numbers for anyone who needs them. Choosing a display is not choosing a favourite — it is matching the display to the question.

Building a line graph that tells the truth

A line graph is a promise too: the promise that a reader who was never in the room can plot the same points from your table and get the same picture. Six steps keep the promise.

Mean bounce height of a tennis ball against drop height (simulated data for practice)



1 Draw two axes. The variable you set — the independent variable, drop height — goes on the horizontal axis. The variable you measure — the dependent variable, bounce height — goes on the vertical axis.

2 Make each axis long enough to hold the largest value.

3 Label each axis with the quantity and its unit.

4 Choose a scale in equal, easy steps (here 20 cm and 10 cm) so the points spread across most of the grid.

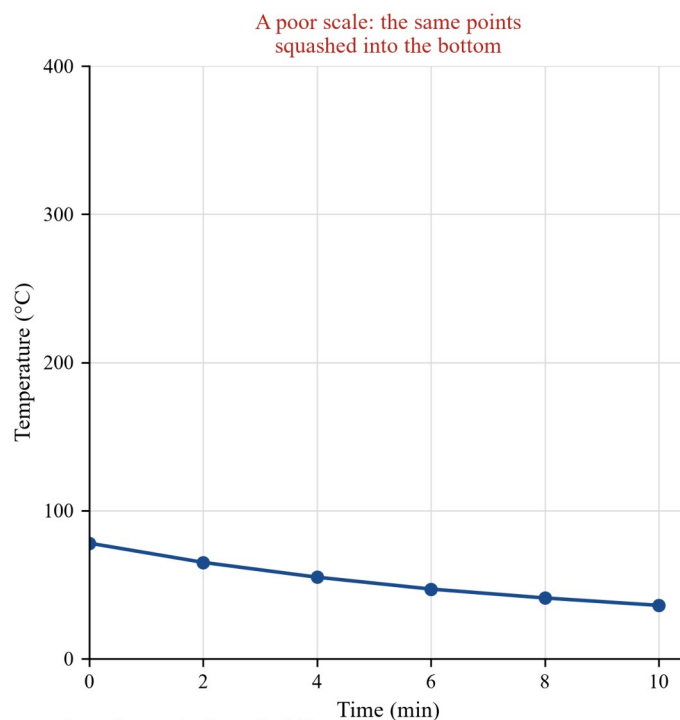
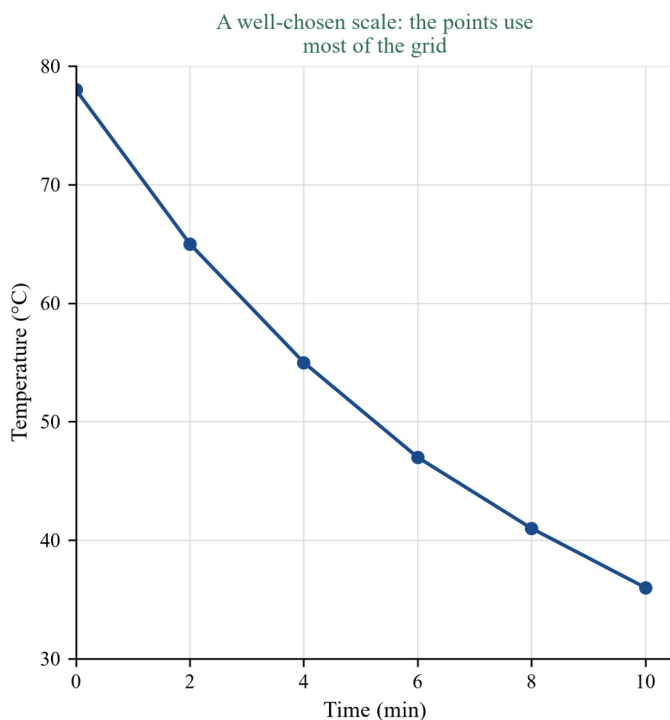
5 Plot each pair as a small, clear point — here, the mean bounce height at each drop height.

6 Join the points dot to dot. The shape of the line is the pattern in the data.

A hand-built line graph of the bounce data on bare grid paper, mean bounce height (cm) against drop height (cm), with six numbered badges marking the construction steps — 1 axes drawn and named with units, 2 an even scale that uses most of the grid, 3 points plotted carefully from the table, 4 points joined dot to dot with a thin line, 5 a title above the graph — beside a checklist of the same six steps: title; axes labelled with quantity and unit; even scale using most of the grid; points plotted from the table; points joined dot to dot; and the graph checked against the table, labelled “simulated data for practice”.

1. **Axes, named with quantity and unit.** The thing you chose (drop height) runs along the horizontal axis; the thing you measured (bounce height) runs up the vertical axis. Each axis is labelled like a table heading: name and unit, “Drop height (cm)”.
2. **An even scale that uses most of the grid.** Equal steps along the axis — 0, 20, 40, 60, 80, 100 — and the points spread across most of the paper. A scale is a set of evenly spaced marks; squeezing the points into a corner throws the picture away.
3. **Points plotted from the table,** one cross or dot per pair of values, carefully.
4. **Points joined dot to dot** with a thin straight line. In this book, that is the joining rule: dot to dot, each measured point to the next.
5. **A title** that says what the graph shows.
6. **A check against the table** — read one point back off the graph and compare it with the table.

The scale does more work than any other step, and it is the step most often done badly. Here is the same cooling data on two scales. Same numbers; only the scale differs.



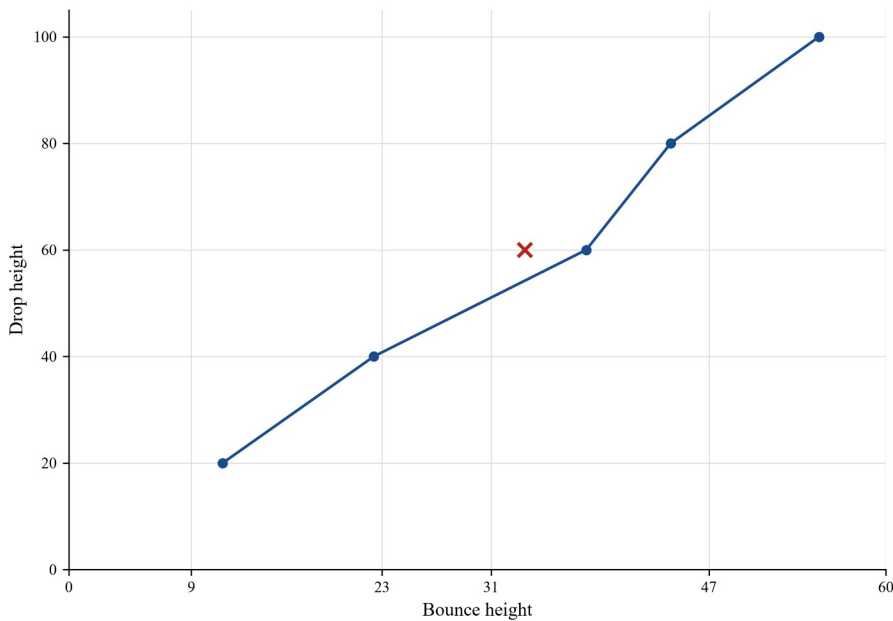
Cooling water — simulated data for practice. Same data; only the scale differs.

Two line graphs of the same cooling-water data — temperature 78, 65, 55, 47, 41, 36 °C at times 0, 2, 4, 6, 8, 10 min. Left, green title “A well-chosen scale: the points use most of the grid”: vertical axis from 30 to 80 °C in steps of 10, the falling curve filling the grid and its steep-then-gentle shape clearly visible. Right, red title “A poor scale: the same points squashed into the bottom”: vertical axis from 0 to 400 °C, the same points pressed flat against the bottom axis so the shape is invisible. Caption: “Cooling water — simulated data for practice. Same data; only the scale differs.”

On the left, the shape is visible at a glance: the water cools quickly at first, then more and more slowly. On the right, the same data is squashed into the bottom fifth of the grid and the shape is gone. A good scale starts at or just below the smallest value, ends at or just above the largest, and moves in easy steps — 1, 2, 5 or 10 and their tens-multiples — so that a reader can place any value without a calculator.

Try it 2 — spot the five faults (VC2S8I04, VC2M7A04)

The graph below was handed in with the bounce investigation. It has exactly five faults against the six-step checklist. Find all five and, for each, name the rule it breaks.



- 1 The axes are swapped — the variable you set goes on the horizontal axis, the one you measure goes on the vertical axis.
- 2 No units on either axis label.
- 3 The horizontal scale jumps in uneven steps (9, then 14, then 8, then 16...) — use equal, easy steps.
- 4 One point is plotted in the wrong place — the red × shows where it belongs.
- 5 No title saying what the graph shows.

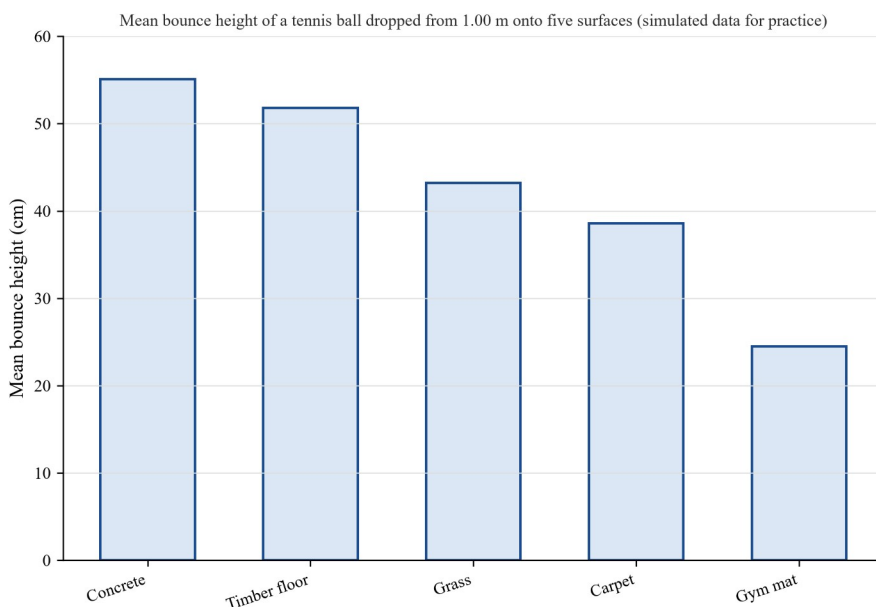
Five faults — find them, then redraw it properly.
simulated data for practice

A faulty line graph of the bounce data with five faults to find: the axes are swapped (bounce height runs along the horizontal axis, drop height up the vertical axis), the axis labels carry no units, the horizontal scale is uneven (tick marks at 0, 9, 23, 31, 47, 60 with equal spacing for unequal steps), one point is plotted in the wrong place (a point at 38 where the table's 33.5 belongs, the true position marked with a red cross), and there is no title, labelled "simulated data for practice".

Hint: check the axes, the units, the scale, every point against the table, and the title. A graph read back point by point against its table is a graph you can trust.

Column graphs: the rules

When the data is **categories** — named groups, not a number scale — the display is a column graph. The surfaces investigation asks *which surface, and how do the surfaces compare?* Five surfaces, five columns.



- 1 One column for each category — here, each surface.
- 2 All columns the same width.
- 3 A gap between columns — the categories are separate things, not a number scale.
- 4 Every column labelled with its category.
- 5 The vertical axis shows the measured quantity, with its unit.
- 6 A title says what the whole graph shows.

A column graph titled "Mean bounce height of a tennis ball dropped from 1.00 m onto five surfaces (simulated data for practice)" with five separated equal-width columns — Concrete 55.1, Timber floor 51.8, Grass 43.2, Carpet 38.6, Gym mat 24.5 cm — beside six numbered rules: 1 one column for each category; 2 all columns the same width; 3 a gap between columns, because the categories are separate things, not a number scale; 4 every column labelled with its category; 5 the vertical axis shows the measured quantity, with its unit; 6 a title says what the whole graph shows.

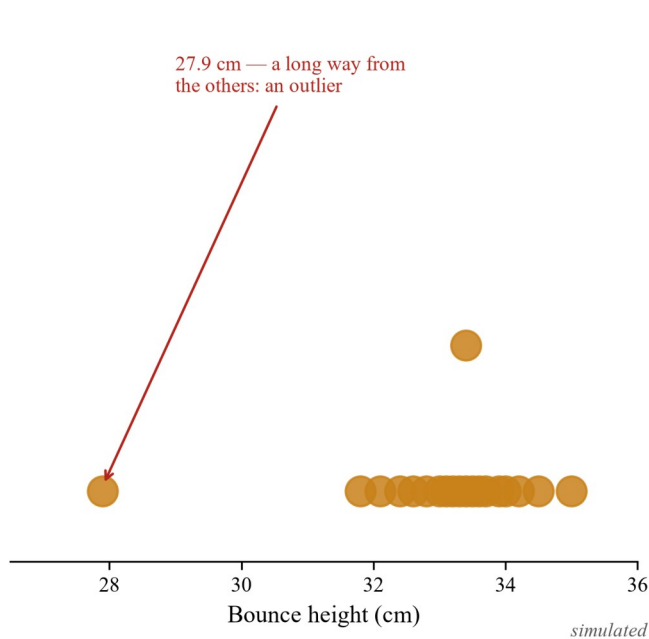
The gap rule is the one that tells a column graph from a line graph. Gaps say *these are separate things* — concrete is not a step on the way to carpet. If the horizontal axis were a number scale with equal steps, the points would belong on a line graph instead. Columns of one width, a labelled category under each, the measured quantity and its unit on the vertical axis, and a title over the top: that is the whole contract.

Showing spread: dot plots and stem-and-leaf plots

Now a different question again. Twenty students each dropped a tennis ball from 60.0 cm and measured one bounce height. There is no category to compare and no pair of numbers to relate — there is one quantity, measured twenty times, and the question is *how are the twenty values spread out?*

Dot plot — twenty single measurements from a 60.0 cm drop

Stem-and-leaf plot — the same twenty values



Stem	Leaf
27	9
31	8
32	1 4 6 8
33	0 1 2 3 4 4 5 6 7 9
34	0 2 5
35	0

Key: 33 | 4 means 33.4 cm

Stem = whole centimetres · Leaf = tenths of a centimetre

Two panels of the same twenty bounce heights. Left: a dot plot — one dot per value above a number line from 28 to 36 cm, nineteen dots clustered between 31.8 and 35.0 and one dot far to the left at 27.9 with a red arrow labelling it “27.9 cm — a long way from the others: an outlier”. Right: a stem-and-leaf plot of the same values — stems 27 to 35 with leaves, key “33 | 4 means 33.4 cm”, note “Stem = whole centimetres · Leaf = tenths of a centimetre” — captioned “simulated data for practice”.

Both displays keep every value — nothing is averaged away — and both make the same thing visible: nineteen values huddled between 31.8 and 35.0, and one value, 27.9 cm, a long way from the crowd. That far-away value is an **outlier**. Before anything else, an outlier gets checked: a misread ruler, a ball dropped off the edge, a slip of the pen. If it was a mistake, it is corrected or left out, with a note saying so. If it was honestly measured, it stays in — and it stays visible, which is exactly what these two displays do.

The class data also lets us name four processing words used for exactly this:

- the **mean** — share the total out evenly: add the twenty values and divide by 20;
- the **median** — the middle value once the data is in order (with twenty values, the mean of the 10th and 11th);
- the **mode** — the value that appears most often;
- the **range** — largest value minus smallest value: how spread out the data is.

For our twenty values: the mean is $661.4 \div 20 = 33.07$, reported as 33.1 cm; the median is the mean of 33.3 and 33.4, which is 33.35 cm; the mode is 33.4 cm; and the range is $35.0 - 27.9 = 7.1$ cm. Take the outlier away and the range shrinks to $35.0 - 31.8 = 3.2$ cm, while the median stays much the same. That contrast — the summary that jumps

when one value misbehaves, and the one that holds steady — is the whole reason for knowing more than one summary.

Processing with spreadsheet formulas

A spreadsheet is a grid of **cells**, and every cell has an address: a column letter and a row number. The cell in column B, row 2 is B2. Type a number into a cell and the cell shows the number. Type a **formula** — which always begins with an equals sign — and the cell shows the formula's answer.

Formula bar

E2	=AVERAGE(B2:D2)
----	-----------------

	A	B	C	D	E
1	Drop height (cm)	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	Mean bounce height (cm)
2	20.0	11.4	10.8	11.6	11.2667
3	40.0	22.5	21.9	22.8	22.4000
4	60.0	33.6	32.8	34.0	33.4667
5	80.0	44.2	43.6	44.8	44.2000
6	100.0	55.0	54.4	55.8	55.0667

The shaded cell is E2: column E, row 2

- Every cell has an address: the column letter first, then the row number.
- A range names a block of cells: B2:D2 is the three trial cells in row 2.
- Every formula starts with =.
- =AVERAGE(B2:D2) adds the three trials and divides by 3.

A spreadsheet grid showing the bounce trials, with column letters A to E across the top and row numbers 1 to 6 down the side. Row 1 holds the headings “Drop height (cm)”, “Trial 1 (cm)”, “Trial 2 (cm)”, “Trial 3 (cm)”, “Mean bounce height (cm)”. Cell E2 is selected and highlighted, the formula bar above the grid reads =AVERAGE(B2:D2), and the mean column shows the raw answers 11.2667, 22.4000, 33.4667, 44.2000, 55.0667, labelled “simulated data for practice”.

The formula =AVERAGE (B2 : D2) says: take the cells from B2 across to D2 — the three trials of the 20.0 cm drop — and find their mean. The cell answers 11.266667. The same three numbers could be processed with the plain-arithmetic formula = (B2+C2+D2) / 3 — same answer, same meaning. Formulas can also hold the range: =MAX (B2 : D2) -MIN (B2 : D2) gives largest trial minus smallest trial. That is the E06 habit: simple formulas, pointed at the right cells, doing the processing.

And here is the spreadsheet's best trick. A formula copied down a column carries its pattern with it: copy =AVERAGE (B2 : D2) down one row and it becomes =AVERAGE (B3 : D3) , pointed at the next row's trials. Write the formula once, fill it down, and every row is processed.

	A	B	C	D	E
1	Drop height (cm)	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	Mean bounce height (cm)
2	20.0	11.4	10.8	11.6	=AVERAGE(B2:D2)
3	40.0	22.5	21.9	22.8	=AVERAGE(B3:D3)
4	60.0	33.6	32.8	34.0	=AVERAGE(B4:D4)
5	80.0	44.2	43.6	44.8	=AVERAGE(B5:D5)
6	100.0	55.0	54.4	55.8	=AVERAGE(B6:D6)

1 Write the mean formula once in E2, then fill it down the column.

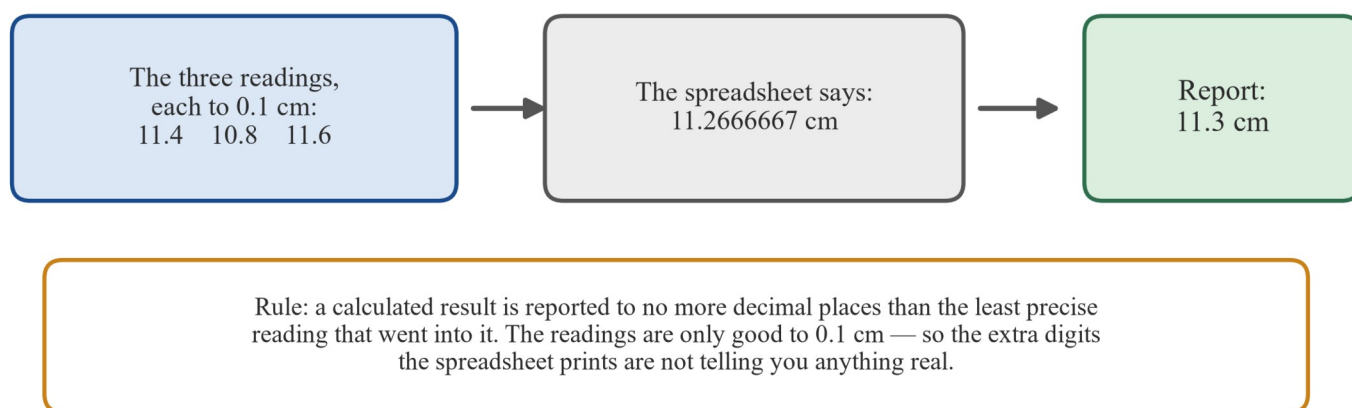
2 Each copied formula points at its own row: B3:D3, then B4:D4, and so on — the cell references move with it.

3 The answers keep many decimal places — 11.2667, 33.4667... Your report still rounds each mean to 0.1 cm: 11.3, 22.4, 33.5, 44.2, 55.1.

The same spreadsheet with the mean column now showing the formulas it contains — =AVERAGE(B2:D2), =AVERAGE(B3:D3), =AVERAGE(B4:D4), =AVERAGE(B5:D5), =AVERAGE(B6:D6) — a green “fill down” arrow running down beside the column, and three numbered notes: 1 write the mean formula once in E2, then fill it down the column; 2 each copied formula points at its own row, the cell references moving with it; 3 the answers keep many decimal places, 11.2667, 33.4667, but the report still rounds each mean to 0.1 cm: 11.3, 22.4, 33.5, 44.2, 55.1, labelled “simulated data for practice”.

One warning travels with the trick. The spreadsheet happily prints 11.2666667, but the readings that went into it were only good to 0.1 cm. The extra digits are not telling you anything real. The rounding rule (VC2M7N04) is: **report a calculated result to no more decimal places than the least precise reading that went into it.**

Reporting a mean — how many decimal places?



Three boxes joined by arrows: “The three readings, each to 0.1 cm: 11.4 10.8 11.6” leading to “The spreadsheet says: 11.2666667 cm” leading to “Report: 11.3 cm”; below, a rule box: “Rule: a calculated result is reported to no more decimal places than the least precise reading that went into it. The readings are only good to 0.1 cm — so the extra digits the spreadsheet prints are not telling you anything real.”

The spreadsheet does the processing; you do the judging. It calculates, and you decide what the answer is worth. That division of labour — machine calculates, human judges — is the whole of this part of the pipe.

Try it 3 — write the formulas (VC2S8I04.E06)



A student's spreadsheet holds three trials of a rolling-marble time, in seconds: B4 shows 4.2, C4 shows 4.5 and D4 shows 4.4. Column E is for the mean and column F is for the range.

1. Write the formula, using AVERAGE, that goes in E4.
2. Write the formula, using MAX and MIN, that goes in F4.
3. The student fills both formulas down to row 9. Write what E9 and F9 contain after the fill.

Try it 4 — report the mean (VC2M7N04)

Each line below gives the precision of the readings and the number a spreadsheet printed for their mean. Write the mean as it should be reported.

1. Readings to 0.1 cm; spreadsheet says 22.4000000 cm.
2. Readings to 0.1 s; spreadsheet says 43.2666667 s.
3. Readings to whole cm; spreadsheet says 87.6666667 cm.
4. Readings to 0.1 °C; spreadsheet says 36.5000000 °C.

Worked examples

Example 1 (scaffolded) — from cooling notes to a finished line graph

Use the cooling notes from Try it 1: water cooling for 10 minutes, read every 2 minutes.

Working	Comment
Two measured numbers, one changing over time → line graph.	The choice question: time is set, temperature is measured. Not categories, not a spread of one quantity.
Table headings: "Time (min)" and "Temperature (°C)"; rows 0 to 10 in order.	Unit in the heading once; the chosen thing (time) leads.
Horizontal axis: time, 0 to 10 min, step 2. Vertical axis: temperature, 30 to 80 °C, step 10.	The scale starts just below the smallest value (36) and ends just above the largest (78), in easy steps, using most of the grid.
Plot (0, 78), (2, 65), (4, 55), (6, 47), (8, 41), (10, 36); join dot to dot.	One point per row of the table; the joining rule for this book.
Title: "Cooling of a cup of hot water over 10 minutes". Finding: the temperature falls quickly at first, then more and more slowly.	The title names the investigation; the finding describes the shape in words.

Example 2 (scaffolded) — spreadsheet means and the rounding rule

A marble rolls down a ramp from four starting heights; the distance it rolls on the flat is measured in whole centimetres, three trials each. Process the table with a spreadsheet and report each mean.

Working	Comment
E2: =AVERAGE (B2 : D2) gives $(42 + 44 + 43) \div 3 = 43.0$	The formula is written once and filled down; each row's formula points at its own trials.
Row 2 reports 43 cm; row 3, $(88 + 85 + 90) \div 3 = 87.666\dots$, reports 88 cm.	Readings are whole centimetres, so a mean is reported to whole centimetres — 87.666... rounds to 88.
Row 4: $(131 + 128 + 134) \div 3 = 131.0$, reports 131 cm; row 5: $(176 + 172 + 180) \div 3 = 176.0$, reports 176 cm.	A mean that lands exactly on a reading still obeys the same rule: no extra decimal places.
Finding: the higher the marble starts, the further it rolls on the flat.	One sentence, in words, from the processed column.

Example 3 — the surfaces investigation, chosen and read

Five surfaces are categories, so the display is a column graph: one column per surface, gaps between, equal widths, “Mean bounce height (cm)” on the vertical axis, and a title. Reading it back in words: concrete returns the highest bounce at 55.1 cm and gym mat the lowest at 24.5 cm; every softer, thicker surface gives a lower bounce, with the biggest single drop between carpet and gym mat. The finding in one sentence: *the harder the surface, the higher the tennis ball bounces*. Notice what was not needed: no joining line (the surfaces are separate things, not a number scale), and no mean-of-trials story, because each column already shows a mean.

Example 4 — the class data, and what an outlier does to a mean

The twenty bounce heights cluster close together, with one outlier at 27.9 cm. With the outlier in, the mean is 33.1 cm and the range is 7.1 cm. With the outlier checked and set aside (it was, let us say, a misread ruler — noted in the report), the mean of the remaining nineteen is $633.5 \div 19 = 33.3$ cm and the range is 3.2 cm. The median is 33.35 cm either way — it does not move much. So the report says: a typical bounce height from a 60.0 cm drop was about 33.4 cm, with values spread across roughly 3.2 cm — and the one far-off reading is named as an outlier rather than quietly averaged in. The spread displays (dot plot, stem-and-leaf) earned their place: they made the outlier impossible to miss, which a mean on its own never would have done.

Practice questions

Q1 (scaffolded). A student’s table is shown below.

Bounce height	trial 1	trial 2
concrete	55.1	54.9
carpet	24.5	25.1

Rewrite it as a tidy results table, fixing three faults. Name each fault as you fix it.

Q2 (scaffolded). Match each data set to the display that answers its question: *column graph, line graph, dot plot or stem-and-leaf plot, or a table*.

1. The number of students in each of five house colours.
2. The length of a candle measured every hour as it burns.
3. Thirty reaction times, in milliseconds, to see their spread.
4. The exact bounce heights from Table A, for a reader who will re-process them.

Q3 (scaffolded). The six line-graph steps below are out of order. Rearrange them into the order this subtopic uses.

A. Join the points dot to dot. B. Add a title that says what the graph shows. C. Check one point back against the table. D. Choose an even scale that uses most of the grid. E. Draw and name the axes: the chosen thing horizontal, the measured thing vertical. F. Plot one point per row of the table.

Q4 (scaffolded). A spreadsheet holds three repeat readings of a length, to 0.1 cm: B2 shows 12.1, C2 shows 12.9 and D2 shows 12.5.

1. Write the formula, using AVERAGE, that goes in E2.
2. Work out what E2 displays.
3. The formula is filled down to E3 for the next row’s readings (13.2, 12.8, 13.0). What does E3 contain as a formula, and what does it display?

Q5 (scaffolded). Report each spreadsheet mean as it should be reported, using the rounding rule.

1. Readings to 0.1 s; spreadsheet says 43.2666667 s.
2. Readings to whole cm; spreadsheet says 55.25 cm.

Q6 (scaffolded). Read this stem-and-leaf plot of bounce heights (cm). Key: 31 | 1 means 31.1 cm.

30		2	5	8
31		1	1	4
32		0	6	

Find: the number of values; the smallest value; the range; and the mode.

Q7. These notes were written during a practical: *cup of hot water, temp every 2 min: $0 \rightarrow 78$, $2 \rightarrow 65$, $4 \rightarrow 55$, $6 \rightarrow 47$, $8 \rightarrow 41$, $10 \rightarrow 36$, degrees C.* Write a tidy results table for them. (2 marks)

Q8. Using your table from Q7, describe the line graph you would construct: name what goes on each axis with its unit, give a sensible scale for each axis, and say how the points are joined. (3 marks)

Q9. A column graph is handed in with these features: the columns touch each other and have different widths; the vertical axis is labelled “Bounce height” with no unit; every column is labelled with its surface; there is a title. Name two faults and the rule each one breaks. (2 marks)

Q10. A line graph of the cooling water is handed in with the time on the vertical axis and the temperature on the horizontal axis, and a horizontal scale marked 0, 1, 2, 5, 6, 10 at equal spacing. Name the two faults. (2 marks)

Q11. A spreadsheet holds the bounce trials exactly as in Table A: column A the drop heights, columns B, C and D the three trials, rows 2 to 6. Write the formula that goes in:

1. E2, to give the mean of the three trials;
2. F2, to give the range of the three trials using MAX and MIN;
3. and say what filling E2 and F2 down to row 6 does. (3 marks)

Q12. The spreadsheet prints 33.4666667 for the mean of the trials 33.6, 32.8 and 34.0 cm.

1. Write the value as it should be reported.
2. Say in one sentence why the extra digits are not kept. (2 marks)

Q13. Seven groups time a toy car over one metre, in seconds: 4.2, 4.5, 4.4, 4.6, 4.3, 4.5, 9.1.

1. Identify the outlier.
2. Find the median of the seven values.
3. Say which of the mean or the median better describes a typical time, and why. (3 marks)

Q14. The means of the bounce investigation are 11.3, 22.4, 33.5, 44.2 and 55.1 cm for drop heights 20.0, 40.0, 60.0, 80.0 and 100.0 cm. Write a one-sentence finding for the line graph, including roughly how the two quantities are related. (2 marks)

Answers

Q1. Faults fixed: no title (add one); no units and no quantity names in the headings (headings become “Surface”, “Trial 1 (cm)”, “Trial 2 (cm)”; categories not in a named first column in a sensible order (a “Surface” column leads). Rewritten table below in solutions.

Q2. 1 column graph · 2 line graph · 3 dot plot or stem-and-leaf plot · 4 a table.

Q3. E, D, F, A, B, C.

Q4. 1 =AVERAGE (B2 : D2) · 2 12.5 · 3 =AVERAGE (B3 : D3) , displaying 13.0.

Q5. 1 43.3 s · 2 55 cm.

Q6. 9 values; smallest 30.2 cm; range 2.4 cm; mode 31.1 cm.

Q7. A titled two-column table, headings “Time (min)” and “Temperature (°C)”, rows (0, 78) to (10, 36) in order.

Q8. Horizontal axis time 0–10 min in steps of 2, labelled “Time (min)”; vertical axis temperature 30–80 °C in steps of 10, labelled “Temperature (°C)”; points plotted and joined dot to dot; title added.

Q9. Touching, unequal-width columns break the gaps-and-equal-widths rule (categories are separate things); “Bounce height” without “(cm)” breaks the unit-in-the-heading rule.

Q10. The axes are swapped (the chosen thing, time, goes horizontal); the scale is uneven (equal spacing for unequal steps 0–1–2–5–6–10).

Q11. 1 =AVERAGE (B2 : D2) · 2 =MAX (B2 : D2) –MIN (B2 : D2) · 3 each copied formula points at its own row, so E6 shows the mean and F6 the range of the 100.0 cm drop’s trials.

Q12. 1 33.5 cm · 2 the readings were only good to 0.1 cm, so extra digits say nothing real.

Q13. 1 9.1 s · 2 4.5 s · 3 the median, because the outlier drags the mean up while the median stays much the same.

Q14. As the drop height increases, the mean bounce height increases — to a little over half the drop height.

Fully-worked solutions

Q1. The three faults, each worth its fix: no title, so add “Bounce height of a tennis ball on two surfaces” (*the title promise*); headings with no quantity names or units, so they become “Surface”, “Trial 1 (cm)” and “Trial 2 (cm)” (*unit in the heading once*); and the categories buried under a “Bounce height” heading, so a named “Surface” column leads the table (*the thing you choose goes first*). The rewritten table:

Surface	Trial 1 (cm)	Trial 2 (cm)
Concrete	55.1	54.9
Carpet	24.5	25.1

Q2. 1 House colours are categories → column graph. 2 A measured length changing over time → line graph. 3 Many measurements of one quantity, to see the spread → dot plot or stem-and-leaf plot. 4 Exact values for re-processing → a table beats any graph.

Q3. E (draw and name the axes) → D (choose the scale) → F (plot the points) → A (join dot to dot) → B (add the title) → C (check one point back against the table) — the six numbered steps of the line-graph build, in order.

Q4. 1 =AVERAGE (B2 : D2) · 2 $(12.1 + 12.9 + 12.5) \div 3 = 37.5 \div 3 = 12.5$, so E2 displays 12.5. 3 Filled down one row, the formula becomes =AVERAGE (B3 : D3) ; it displays $(13.2 + 12.8 + 13.0) \div 3 = 39.0 \div 3 = 13.0$.

Q5. 1 Readings to 0.1 s → report to one decimal place: 43.3 s. 2 Readings to whole cm → report to whole cm: 55.25 rounds to 55 cm.

Q6. Counting leaves: $3 + 4 + 2 = 9$ values. Smallest: 30.2 cm. Largest 32.6 cm, so range = $32.6 - 30.2 = 2.4$ cm. Mode: 31.1 cm, the only value that appears twice.

Q7. Title “Cooling of a cup of hot water”; headings “Time (min)” and “Temperature (°C)”; rows in order 0 to 10: (0, 78), (2, 65), (4, 55), (6, 47), (8, 41), (10, 36). One mark for headings with units and a title, one for the six correct rows in order.

Q8. Horizontal axis: time, labelled “Time (min)”, 0 to 10 in steps of 2. Vertical axis: temperature, labelled “Temperature (°C)”, 30 to 80 in steps of 10 — starting just below 36 and ending just above 78, so the points use most of the grid. One point plotted per row, joined dot to dot, with a title over the graph. One mark per correct part: axes with units, sensible even scales, points joined dot to dot with a title.

Q9. Fault one: the columns touch and have different widths — the rules are one equal-width column per category with a gap between, because categories are separate things, not a number scale. Fault two: the vertical axis label has no unit — it must read “Bounce height (cm)”. (The labels and title were already correct.)

Q10. Fault one: the axes are swapped — time is the thing chosen, so it belongs on the horizontal axis with temperature up the vertical. Fault two: the scale 0, 1, 2, 5, 6, 10 at equal spacing is uneven — equal spacing must mean equal steps.

Q11. 1 E2: =AVERAGE (B2 : D2) . 2 F2: =MAX (B2 : D2) -MIN (B2 : D2) . 3 Filling down copies each formula with its references moved to its own row: E6 holds =AVERAGE (B6 : D6) and displays 55.0666667, F6 holds =MAX (B6 : D6) -MIN (B6 : D6) and displays 1.4 — so the whole table is processed from one written formula each.

Q12. 1 Readings to 0.1 cm → report 33.5 cm. 2 The extra digits are not kept because the readings were only good to 0.1 cm: a calculated result is reported to no more decimal places than the least precise reading that went into it.

Q13. 1 The outlier is 9.1 s — a long way from the other six, which sit between 4.2 and 4.6. 2 In order: 4.2, 4.3, 4.4, 4.5, 4.5, 4.6, 9.1; the middle (4th) value is 4.5 s. 3 The median. The mean of all seven is $35.6 \div 7 = 5.0857$, about 5.1 s — higher than six of the seven times, dragged up by the one bad one — while the median, 4.5 s, sits in the middle of the six honest readings and describes a typical time.

Q14. The mean bounce height increases as the drop height increases, reaching a little over half of the drop height (55.1 cm from a 100.0 cm drop). One mark for the direction of the pattern, one for the quantitative touch (“a little over half”).

Sources

- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description VC2S8I04 and its elaborations, 2026. vcaa.vic.edu.au — retrieved 2026-08-21.

All numerical series in the figures and questions (the bounce trials and their means, the five surface heights, the twenty-value class data set, the cooling-water curve, the marble-ramp distances, and the small question data sets) are **simulated data for practice**, labelled as such in each figure; they are teaching data, not measurements, and carry no source claim.

Elaboration context used: VC2S8I04 . E06 (simple spreadsheet formulas — the AVERAGE/MAX/MIN formulas, fill-down, and the rounding of processed results). The tables-and-graphs strands are authored from the CD text with the D11 Maths interlock: VC2M7N04 (the reporting-precision rule), VC2M7ST01 (mean, median, mode, range on the class data), VC2M7ST02 (dot plots and stem-and-leaf plots), VC2M7A05 (plotting from a table of values) and VC2M7A04 (interpreting graphs, including the fault-finding tasks).

Teacher-facing note (not student text). 4A owns the tables-and-graphs clause of VC2S8I04; keys, models and mathematical relationships are 4B’s († split delivery, D6). The scope ceiling is held: gradient (VC2M9A04), lines of best fit and scatterplots (VC2M10ST02) and scientific notation (VC2M9M02) are named here only as later learning, never taught; line-graph points are joined dot to dot by house rule for this band. The single elaboration VC2S8I04 . E06 is a thin bank by design (D12): the subtopic is authored from the CD text plus the Maths interlock, and a “used only 1 of 6 elaborations” finding against 4A would be false by design. No Aboriginal and Torres Strait

Islander content is drawn on here: VC2S8I04 carries no such elaborations, and D10's sourced treatments sit in the subtopics the TOC names.

Representing with keys, models and mathematical relationships — and the strengths and limits of each representation

What we teach here — VC2S8I04 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“data and information can be organised and processed by selecting and constructing representations including tables, graphs, keys, models and mathematical relationships” **This subtopic is the partner for**

the keys, models and mathematical relationships clause († split delivery, D6): selecting and constructing keys, models and mathematical relationships to organise and process data and information, and weighing what each representation shows well against what it hides. The owner subtopic **4A** carries the tables-and-graphs clause, and this subtopic leans on 4A’s table and graph craft wherever a key, a model or a formula needs one. **In our words:** a representation is a stand-in — it holds your data or your idea in a form you can work with. 4A gave you the table and the graph. This subtopic adds four more tools to the family: the **key**, which sorts things into named groups by asking yes–no questions; the **model**, which stands in for something too big, too small, too slow, too fast or too dangerous to handle; the **mathematical relationship**, which holds a pattern so exactly that you can calculate any case in it; and the **energy flow diagram**, which shows where energy comes from and where it goes. One habit runs through all of them and is the real point of the subtopic: every representation shows some things well and hides or distorts others, so the skilled move is to *choose* the representation for the job and to *say* what it cannot show. **Achievement-standard extract served here (D13):** 4A is the owner of VC2S8I04, so the extract — *“They select and construct appropriate representations to organise and process data and information.”* — appears in full in 4A’s header; this partner subtopic cites it by reference to that header, and every worked example and question here is written against it. **Elaborations drawn on:** VC2S8I04.E01 (strengths and limitations of physical models, diagrams and virtual simulations, and choosing the most appropriate representation), VC2S8I04.E02 (constructing dichotomous keys from a collection of objects — our pooled-stationery key), VC2S8I04.E03 (constructing representations of physical and chemical change — our sequence of drawings of a change), VC2S8I04.E04 (constructing representations that sort data, including a key read as a sequence of steps and decisions) and VC2S8I04.E05 (energy flow diagrams for a system such as a roller-coaster). The elaborations are contexts for the CD, not a checklist (D12). **Maths interlock (D11):** substituting values into an everyday formula to find an unknown (VC2M7A01) is the whole of the mathematical-relationship craft taught here; designing a sequence of steps and decisions that sorts and classifies by attribute (VC2M7SP04) is what a dichotomous key *is*, and designing **and testing** such an algorithm (VC2M8SP04) is how we check a key before trusting it. Converting metres to centimetres and cubic centimetres to litres in the model and formula examples is the Level 6 unit-conversion skill (VC2M6M01) that this book maintains in practice (§5.2) — it is used, shown step by step, and never re-taught as new. **Scope notes:** the ceiling is held. Tables and graphs are 4A’s clause and are used here only as forms a mathematical relationship can be written in. Energy appears only as flows from one store or form to another; naming the forms precisely and classifying them as kinetic or potential is 16A’s work, and analysing a system for efficiency with a Sankey diagram is 16B’s — an energy flow diagram here says *where* energy goes and *roughly what share*, never an efficiency number. Particle models of states and changes belong to 10A and 10B; distinguishing physical from chemical change is 11B’s; using a key on living things is 7B’s. Gradient and lines of best fit (VC2M9A04, VC2M10ST02) and scientific notation (VC2M9M02) do not appear.

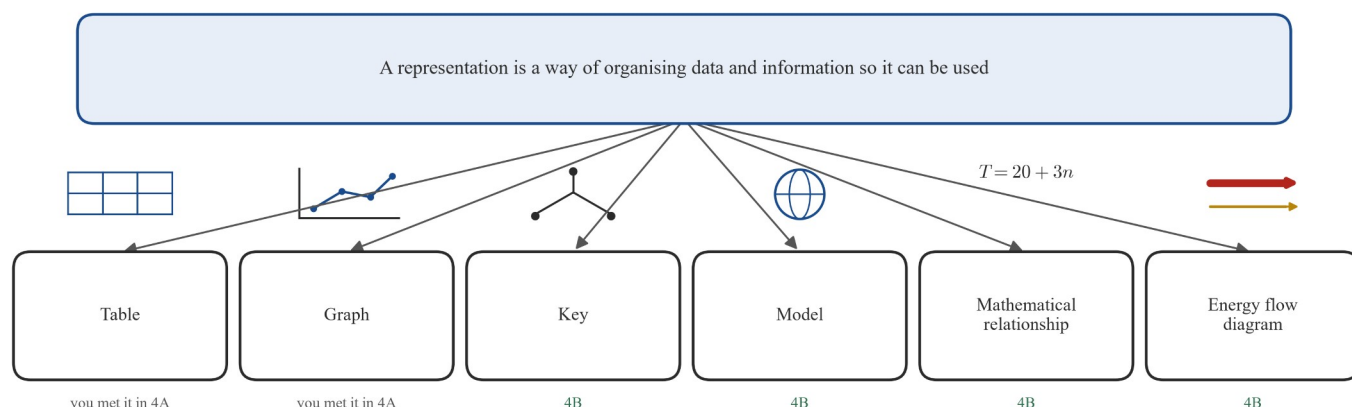
Word watch — *representation, key, dichotomous, model, scale, variable, substitute, algorithm.* A

representation is a way of organising data or an idea so it can be used — a table, a graph, a key, a model, a formula, a diagram. The curriculum’s CD names exactly this family. A **key** is a set of yes–no questions that leads you to the name of an item by its observable features. **Dichotomous** means splitting into two at every step — every question in a dichotomous key offers exactly two answers, so *dichotomous key* is a key in which each step forks two ways. A **model** is a stand-in for a real thing — a globe, a drawing of particles, a simulation on screen — that keeps some features of the real thing and drops others. A **scale** tells you how a model’s sizes compare with the real thing’s: 1:100 reads as “one unit on the model stands for one hundred of the same units in real life”. A **variable** in a formula is a letter standing for a number that can change. To **substitute** is to replace each letter in a formula with its number so the formula can be calculated. An **algorithm** is a sequence of steps and decisions, written so exactly that a person or a computer can follow it without guessing — a key is one, and so is a recipe written as “if this, do that”.

Theory

One job, many tools

4A ended with a promise: a table keeps every exact value, a graph shows a shape. Those are two representations. The CD that both subtopics share names more — keys, models and mathematical relationships — and this subtopic adds the energy flow diagram from the elaborations. Six tools, one job: holding data or an idea in a form you can work with.



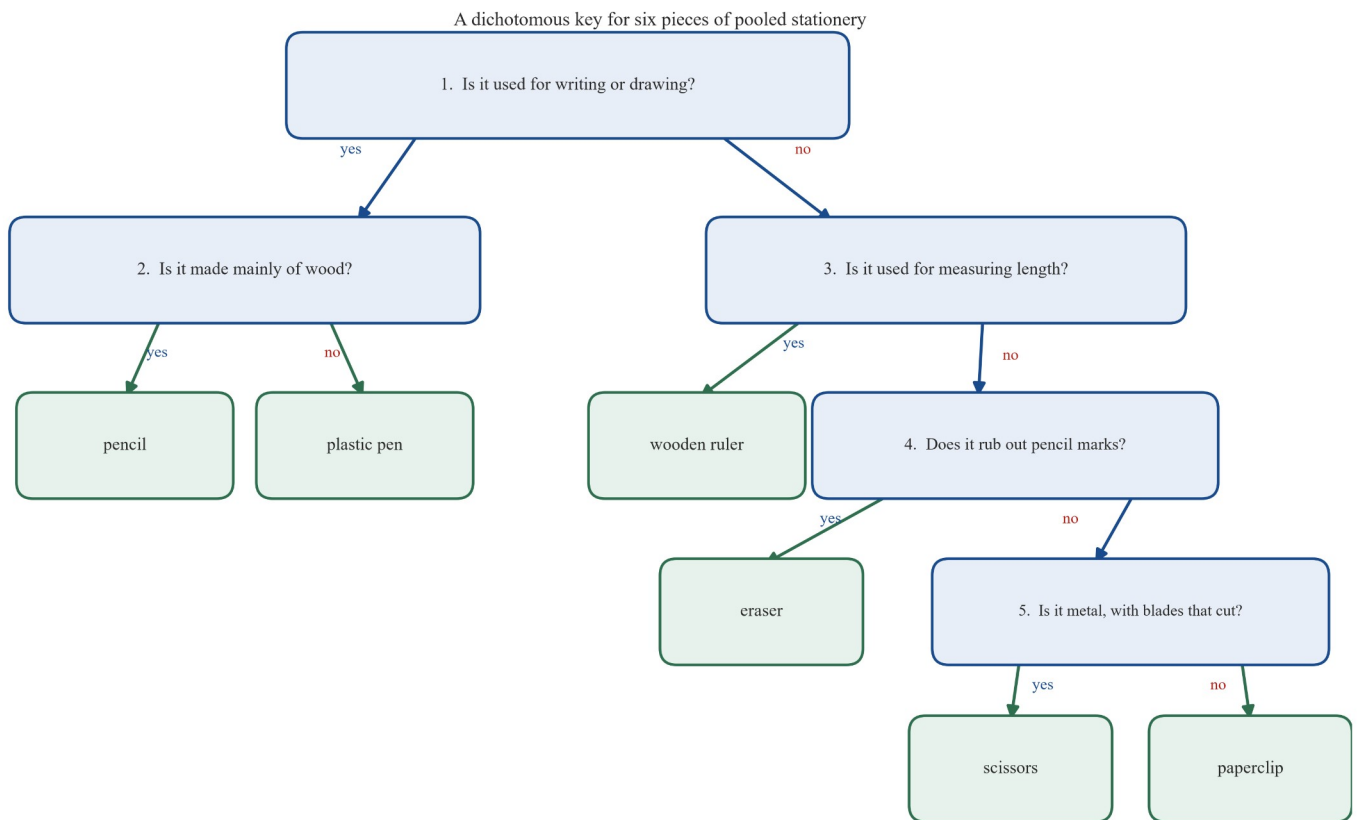
One job, many tools — this subtopic adds the bottom four to the two you already used in 4A

Flow chart titled “A representation is a way of organising data and information so it can be used”, with a banner box across the top and six boxes below it joined by arrows: Table (tagged “you met it in 4A”), Graph (tagged “you met it in 4A”), Key, Model, Mathematical relationship and Energy flow diagram (each tagged “4B”), each box with a small icon — a grid, a rising line graph, a forking tree, a globe, the formula $T = 20 + 3n$, and a wide arrow beside a thin arrow — and the caption “One job, many tools — this subtopic adds the bottom four to the two you already used in 4A”.

The tools are not rivals. A key sorts, a model stands in, a formula calculates, an energy flow diagram traces where energy goes, and a table or a graph from 4A displays measured values. The question is never *which representation is best?* — it is *which representation is best for this job?* And the answer always comes with a second sentence: *and here is what it will not show you.* That pair of sentences is the whole subtopic.

Keys: two answers at every step

Tip out the lost-property tin: a pencil, a plastic pen, a wooden ruler, an eraser, a pair of scissors and a paperclip. Six items, and a key that names each one. Every question offers exactly two answers — yes or no — so the key is **dichotomous**, and each answer sends you down one branch or tells you the name.



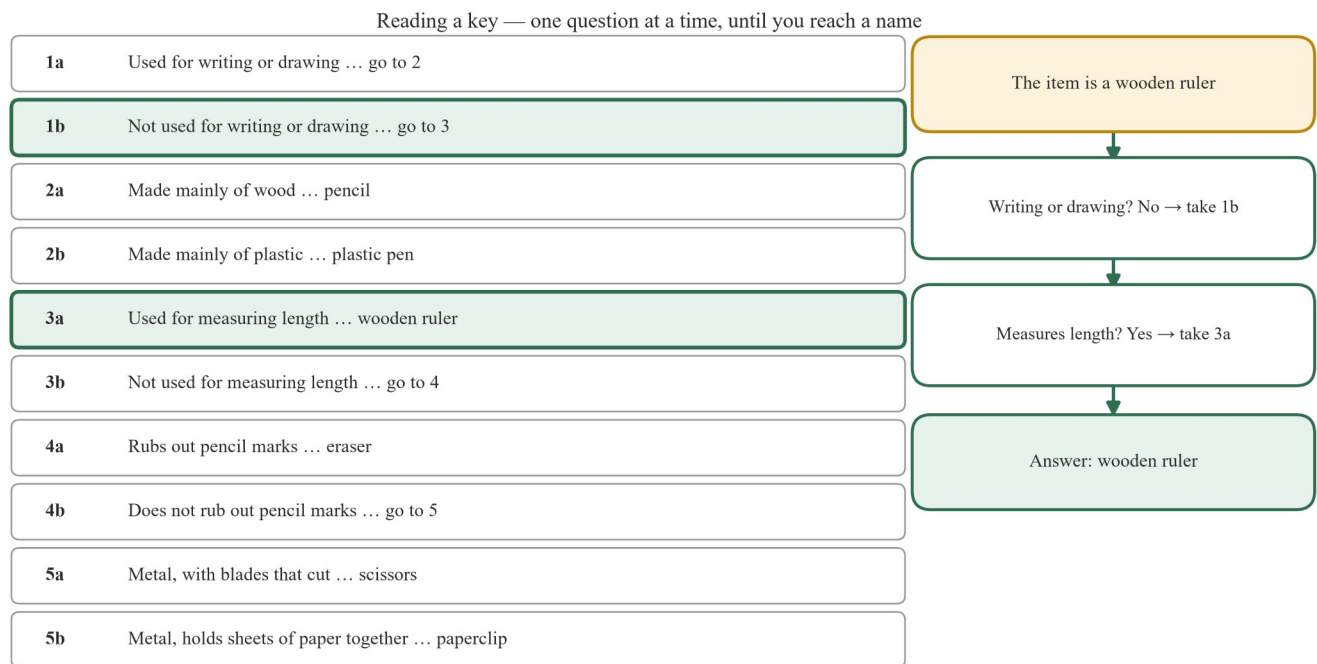
Every question offers exactly two answers — follow one, and only one, branch at a time

Branching diagram titled “A dichotomous key for six pieces of pooled stationery”. Top box: “1. Is it used for writing or drawing?” with a “yes” branch left and a “no” branch right. Left box: “2. Is it made mainly of wood?” forking to leaves “pencil” (yes) and “plastic pen” (no). Right box: “3. Is it used for measuring length?” forking to “wooden ruler” (yes) and to “4. Does it rub out pencil marks?”, which forks to “eraser” (yes) and “5. Is it metal, with blades that cut?”, which forks to “scissors” (yes) and “paperclip” (no). Question boxes are blue, name leaves are green, and the caption reads “Every question offers exactly two answers — follow one, and only one, branch at a time”.

Three rules make a key trustworthy, and all three are on show in the stationery key:

1. **Questions use features you can observe.** “Is it used for measuring length?” is answerable by looking and handling. A question like “does the owner like it?” is not — nobody can observe it.
2. **Each question offers exactly two answers.** That is the dichotomous part. If a question could be answered “sometimes”, the key has a hole in it.
3. **Every item in the set reaches its own leaf.** Follow the six items through: the pencil takes 1-yes, 2-yes; the plastic pen 1-yes, 2-no; the wooden ruler 1-no, 3-yes; the eraser 1-no, 3-no, 4-yes; the scissors 1-no, 3-no, 4-no, 5-yes; and the paperclip 1-no, 3-no, 4-no, 5-no. Six items, six leaves, no sharing.

A key can be drawn as a branching diagram, or written as numbered pairs of lines — **couplets** — with each answer either naming the item or sending you to another couplet. The two forms are the same key in different clothes.



Two couplets were enough here — the key never asked questions 4 or 5 of this item

Two panels titled “Reading a key — one question at a time, until you reach a name”. Left panel: the stationery key written as ten couplet lines, 1a “Used for writing or drawing ... go to 2” through 5b “Metal, holds sheets of paper together ... paperclip”. Right panel: a worked trace for a wooden ruler — “The item is a wooden ruler”, then “Writing or drawing? No → take 1b”, then “Measures length? Yes → take 3a”, then “Answer: wooden ruler”, with the two couplets used highlighted in green and the caption “Two couplets were enough here — the key never asked questions 4 or 5 of this item”.

Reading a key is a walk: ask the question of the item in front of you, take the branch that is true, and stop only at a name. The wooden ruler never meets questions 4 and 5, because a key asks each item only what it needs to ask. Chapter 7 will put this exact tool to work on living things — 7B builds and uses keys for leaves, seeds and small organisms — so the stationery tin is practice for the schoolyard.

Try it 1 — walk the key (VC2S8I04.E02)

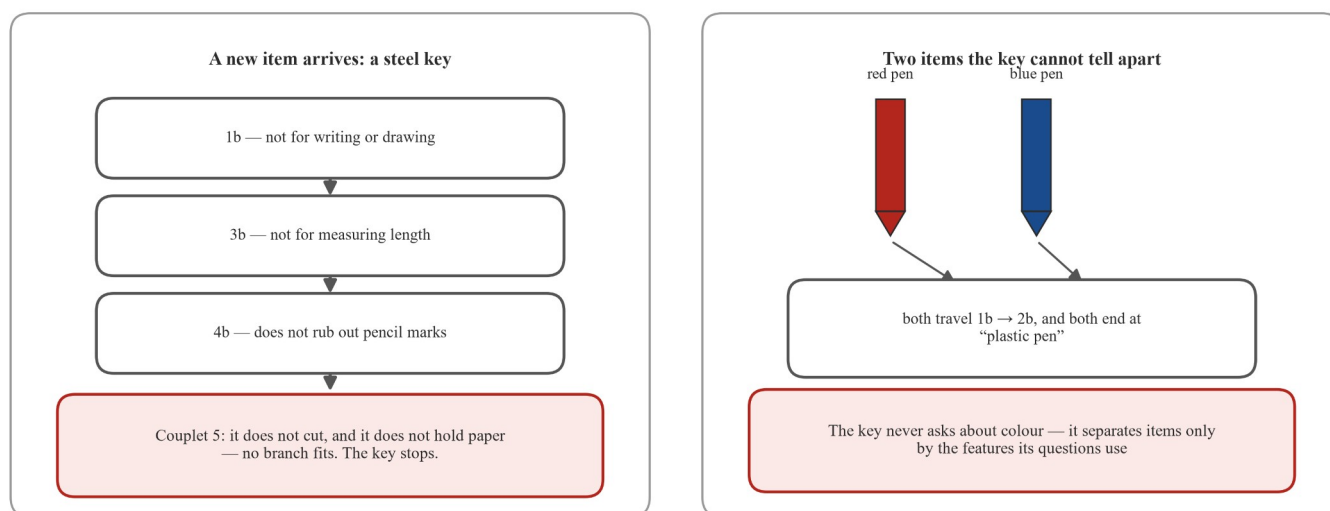
Using the couplet form of the stationery key, write the path (as a list of couplet choices, like 1b, 3a) for each item:

1. the eraser;
2. the scissors;
3. the pencil.

Then state the one couplet at which the paths of the pencil and the plastic pen go their separate ways.

Where keys break

A key is only as good as the set it was built for. Two failures are built into every key, and both are worth naming out loud.

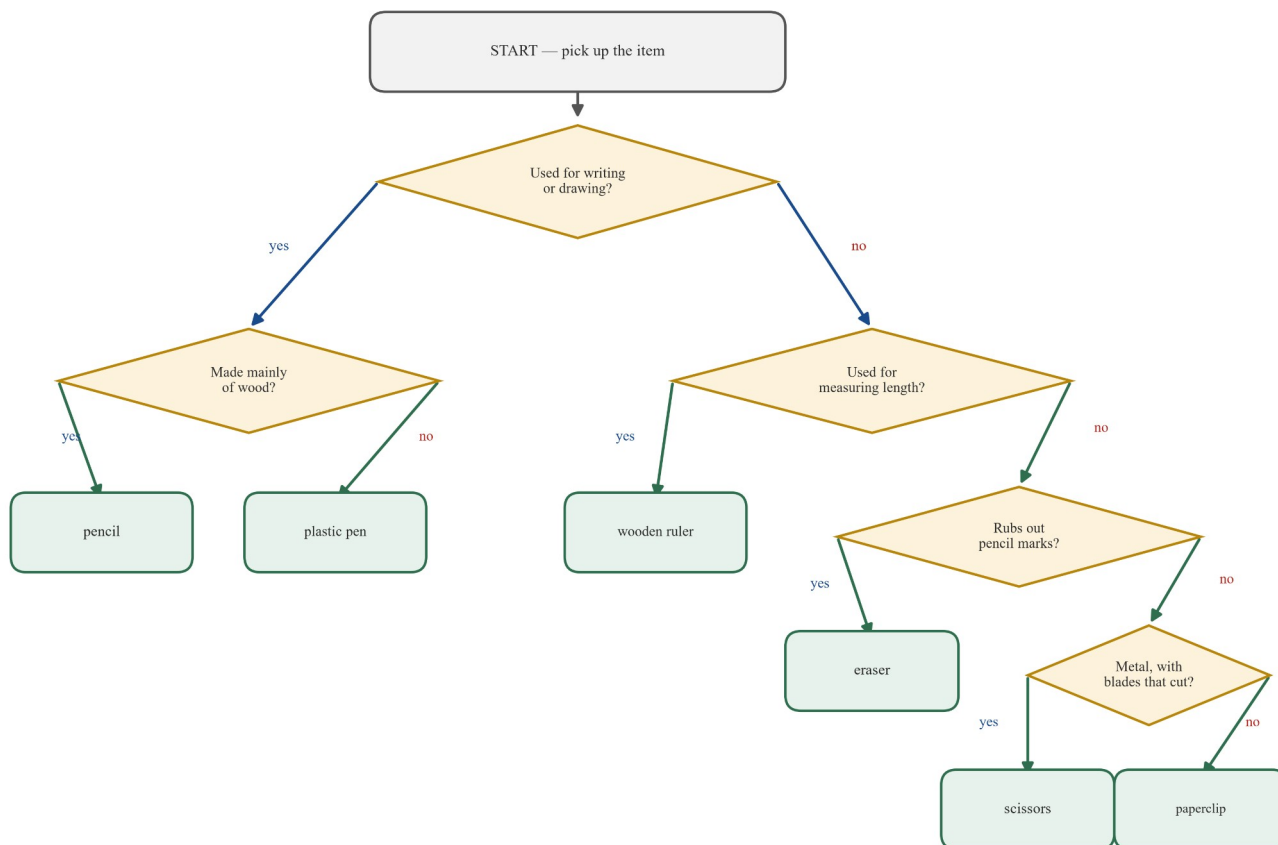


Two panels titled “Two limits of every key: items outside the set, and features it never asks about”. Left panel: “A new item arrives: a steel key” traced down the stationery key — “1b — not for writing or drawing”, “3b — not for measuring length”, “4b — does not rub out pencil marks” — ending in a red box: “Couplet 5: it does not cut, and it does not hold paper — no branch fits. The key stops.” Right panel: a red pen and a blue pen drawn side by side, both arrows leading to one box, “both travel 1b → 2b, and both end at ‘plastic pen’”, above a red box: “The key never asks about colour — it separates items only by the features its questions use”.

The first failure: **an item outside the set**. The steel key is not one of the six items, and the key has no leaf for it — at couplet 5, neither branch is true, and the walk stops. A key identifies members of its own set; handed a stranger, it should stop rather than guess. The second failure: **features the key never asks about**. A red pen and a blue pen walk the same path and end at the same leaf, because colour was never a question. The key is not wrong — it separates items only by the features its questions use, and colour was not one of them. Both failures say the same thing: a key is a tool for a known set and chosen features, not a machine for naming anything.

A key is an algorithm — so test it

Look at the stationery key again with a programmer’s eye. Each yes–no question is a decision; each answer is a step to the next decision or to a name. A sequence of steps and decisions that sorts items by their features is exactly what mathematics calls designing an algorithm that sorts and classifies by attribute (VC2M7SP04) — and mathematics at Level 8 adds the second move: **design and test** the algorithm (VC2M8SP04). Testing a key means walking every item in the set through it and checking that each one ends at its own leaf, then walking one stranger through and checking that the key stops rather than misnames it.



Each diamond is one yes-or-no question — exactly the shape an if-statement takes in a computer program. A key is an algorithm: a sequence of steps and decisions that sorts by features.

Flowchart titled by its caption “Each diamond is one yes-or-no question — exactly the shape an if-statement takes in a computer program. A key is an algorithm: a sequence of steps and decisions that sorts by features.” A grey START box “START — pick up the item” leads to amber decision diamonds: “Used for writing or drawing?” forking yes/no to “Made mainly of wood?” (leaves: pencil, plastic pen) and “Used for measuring length?” (leaf: wooden ruler; no-branch to “Rubs out pencil marks?” with leaf eraser and a final diamond “Metal, with blades that cut?” with leaves scissors and paperclip). Yes-branches end at green name boxes.

The diamond shape is the clue. In a computer program, a decision is written as *if this, do that; otherwise, do the other thing* — an if-statement — and the diamonds above are if-statements drawn as boxes. That is also why E04 names *coding a simple program* as one way to build a sorting representation: the key is the program before it is typed.

Try it 2 — test the key like an algorithm (VC2M8SP04)

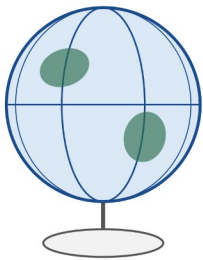
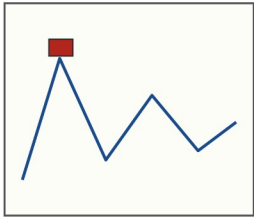
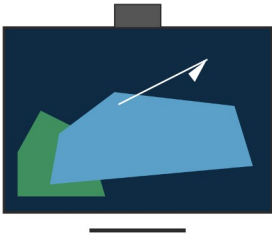
A student builds this key for four shapes: a red circle, a blue circle, a red square and a blue square.

1a The shape is round ... go to 2 · 1b The shape has straight sides ... go to 3 2a The shape is red ... red circle · 2b The shape is blue ... blue circle 3a The shape is red ... red square · 3b The shape is blue ... blue square

1. Walk each of the four shapes through the key and state its leaf.
2. A yellow circle joins the set. State exactly where the key fails it, and which couplet you would change — and to what — so the key works for five shapes.

Models: stand-ins that keep some things and drop others

Some things refuse to sit on a lab bench. Earth is too big, a cell too small, a term of plant growth too slow, a flood too dangerous. A **model** stands in: it keeps the features you need to reason about and drops the rest. Models come in three kinds, and the habit is the same for all three — ask what each shows well, and what it cannot show.

	Physical model a globe of Earth	Drawn model a roller-coaster drawn on paper	Virtual model a flood simulation on screen
			
shows well	You can see it from all sides, hand it around, point at parts	Shows shape and position of parts at a glance; you can add labels	Can run a process again and again, faster or slower
can't show	Not the real size, weight or strength; different materials	Flat — no depth, and not the real size unless it says so	Only as good as the rules it was built from

Three kinds of model, one habit: ask what each one shows well, and what it cannot show

Three columns titled “Three kinds of model, one habit: ask what each one shows well, and what it cannot show”. Column 1 “Physical model — a globe of Earth”: a drawn globe on a stand; green box “shows well: you can see it from all sides, hand it around, point at parts”; red box “can’t show: not the real size, weight or strength; different materials”. Column 2 “Drawn model — a roller-coaster drawn on paper”: a sheet of paper carrying a two-hilled track line with a small red cart at the top of the first hill; green box “shows well: shows shape and position of parts at a glance; you can add labels”; red box “can’t show: flat — no depth, and not the real size unless it says so”. Column 3 “Virtual model — a flood simulation on screen”: a computer screen showing water over land; green box “shows well: can run a process again and again, faster or slower”; red box “can’t show: only as good as the rules it was built from”.

The physical model you can hold — and holding is its limit as well as its strength, because it is made of classroom materials, not real ones. The drawn model is flat and silent about depth: a drawing of the roller-coaster shows the shape of the track and where each hill sits, but not what the drop feels like or how wide the real cart is — and, unless it says it is to scale, not the real sizes either. The virtual model is a set of rules running on a screen — brilliant at running a flood a hundred times in a minute, and exactly as wrong as its rules are. *Only as good as the rules it was built from* is the sentence to remember about every simulation you ever meet.

Scale models — right shape, wrong size, on purpose. A scale model keeps proportions and drops size, and the scale says by how much. The school hall is 25 m long; a 1:100 cardboard model of it makes every length 100 times smaller.

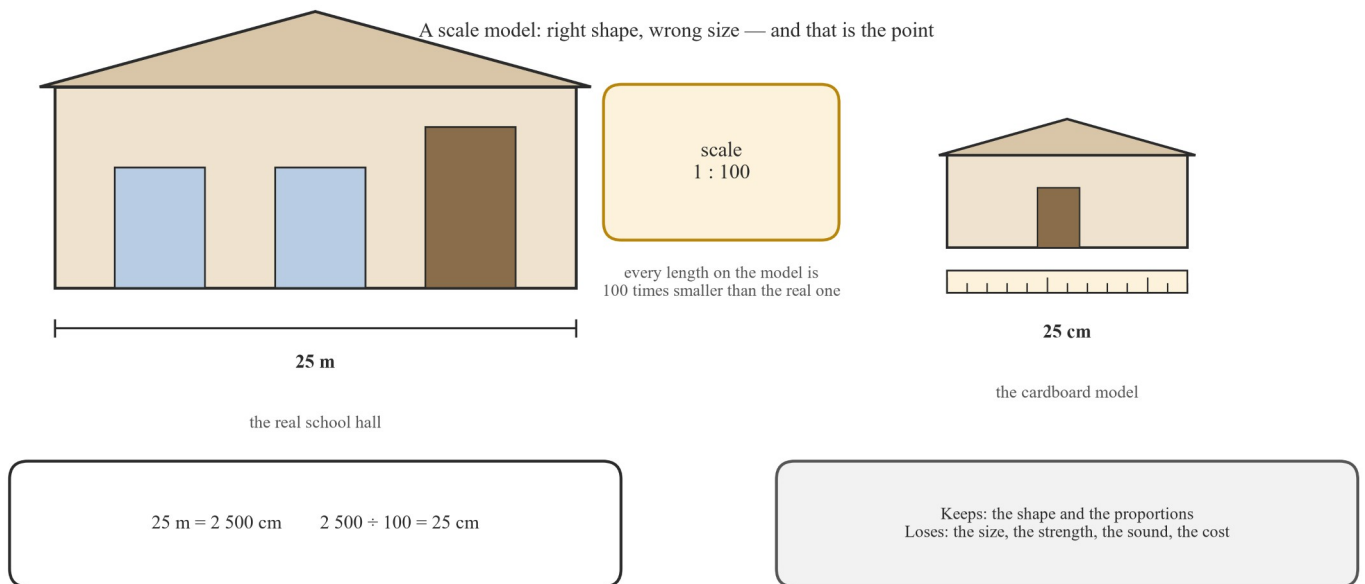


Diagram titled “A scale model: right shape, wrong size — and that is the point”. Left: the real school hall drawn with windows and a door, dimensioned “25 m”. Centre: an amber box “scale 1 : 100” with the note “every length on the model is 100 times smaller than the real one”. Right: a small cardboard model of the same hall above a ruler, dimensioned “25 cm”. Below, a white box shows the working “ $25\text{ m} = 2\,500\text{ cm}$ $2\,500 \div 100 = 25\text{ cm}$ ”, and a grey box lists “Keeps: the shape and the proportions” and “Loses: the size, the strength, the sound, the cost”.

The working uses the Level 6 conversion this book keeps in practice: 25 m is 2 500 cm, and dividing by the scale gives 25 cm. Every other length on the model follows the same rule — a 2 m door becomes $200\text{ cm} \div 100 = 2\text{ cm}$. And the grey box is the evaluation sentence every model earns: what it keeps (the shape and the proportions) and what it loses (the size, the strength, the sound, the cost). A scale model of the hall will not tell you whether the roof holds in a storm, because strength does not scale the way length does.

Try it 3 — name what the model keeps and drops (VC2S8I04.E01)

For each model below, write one sentence of strength and one sentence of limit, in the keeps/loses form used above.

1. A globe of Earth, used to explain why Victoria has summer while Canada has winter (that story is 14A’s — here, judge only the representation).
2. The 1:100 cardboard hall, used to plan where a new drinking fountain could go.

Mathematical relationships: one rule, every case

The school fete runs a sausage sizzle. The stall costs \$20 to set up, and each sausage sold brings in \$3. Say the pattern in words, in symbols, in a table or on a graph, and it is the *same* relationship four times.

1 In words

total money taken
=
\$20 for the stall
+
\$3 for each sausage sold

2 In symbols

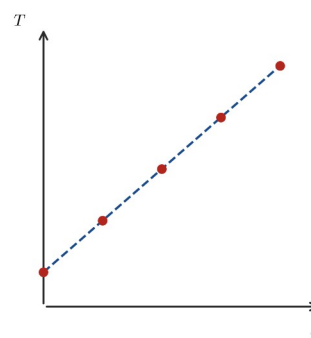
$T = 20 + 3n$
 T = total money (\$)
 n = number of
sausages sold

3 In a table

n	T (\$)
0	20
10	50
20	80
30	110

and at $n = 40$, $T = 140$

4 On a graph

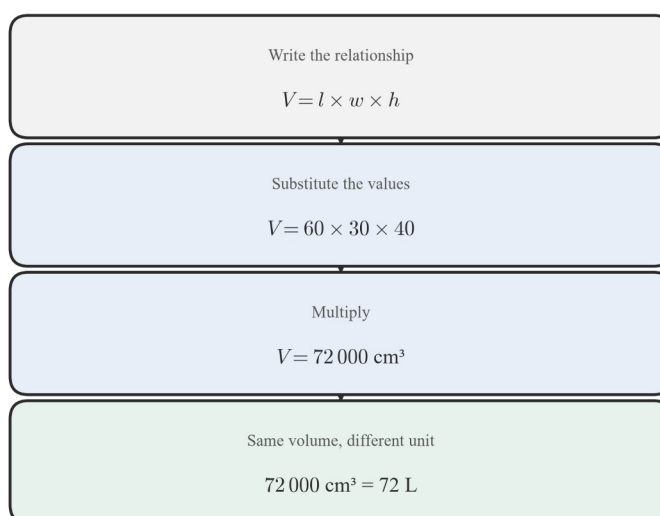
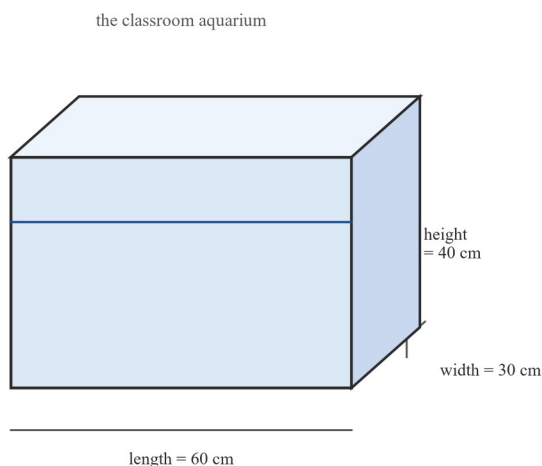


The sausage sizzle: one relationship written four ways — each form is the same information in different clothes

the same rule, drawn

Four panels titled “The sausage sizzle: one relationship written four ways — each form is the same information in different clothes”. Panel 1 “In words”: “total money taken = \$20 for the stall + \$3 for each sausage sold”. Panel 2 “In symbols”: “ $T = 20 + 3n$ ”, with “ T = total money (\$)” and “ n = number of sausages sold”. Panel 3 “In a table”: columns n and T (\$), rows (0, 20), (10, 50), (20, 80), (30, 110), noted “and at $n = 40$, $T = 140$ ”. Panel 4 “On a graph”: axes n (horizontal) and T (vertical) with the points (0, 20), (10, 50), (20, 80), (30, 110), (40, 140) lying on a rising dashed line, noted “the same rule, drawn”.

In the symbol form, T and n are **variables** — letters standing for numbers that can change. Each form has its own strength. Words say the meaning; symbols say the rule in one line; the table keeps exact cases; the graph shows the steady climb at a glance — and the graph itself is 4A’s craft, a line graph of a table of values. The strength the symbol form adds is the one no other form matches: hand it *any* number of sausages and it answers. That act — replacing each letter with its number and calculating — is **substituting**, and mathematics names it directly: substitute values into a formula to determine an unknown (VC2M7A01).



Substituting: replace each letter with its number, then calculate — one line per step

Diagram titled “Substituting: replace each letter with its number, then calculate — one line per step”. Left: a labelled 3-D drawing of the classroom aquarium, dimensioned length = 60 cm, width = 30 cm, height = 40 cm. Right: four step boxes joined by down-arrows — “Write the relationship: $V = l \times w \times h$ ”; “Substitute the values: $V = 60 \times 30 \times 40$ ”; “Multiply: $V = 72\,000\text{ cm}^3$ ”; “Same volume, different unit: $72\,000\text{ cm}^3 = 72\text{ L}$ ”.

The aquarium formula is given — the *why* of volume belongs to a later chapter and to maths — and the job here is the substituting: write the relationship, replace each letter with its number, calculate, one line per step. The last line is the maintained Level 6 conversion again: $1\,000\text{ cm}^3$ is 1 L, so $72\,000\text{ cm}^3$ is 72 L. Two cautions travel with every formula. First, a formula only knows its own letters: $T = 20 + 3n$ knows nothing about the weather on fete day. Second, a formula will happily calculate nonsense — put in $n = 3.5$ sausages and it answers $T = 30.5$ without blinking. Checking that an answer makes sense is your job, not the formula’s.

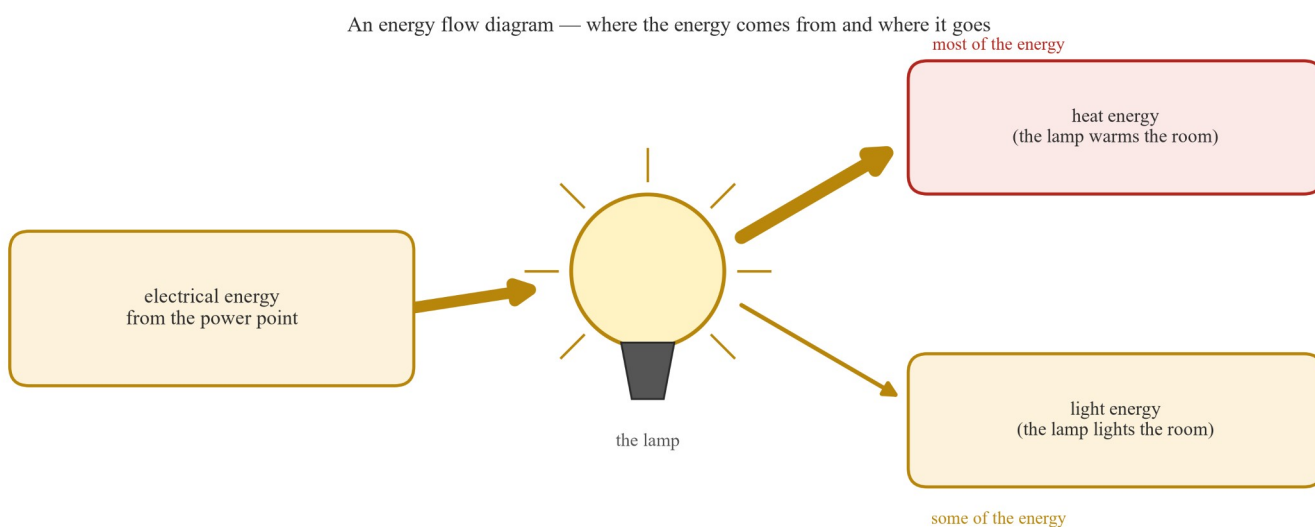
Try it 4 — substitute (VC2M7A01)

Using $T = 20 + 3n$ for the sausage sizzle:

1. substitute $n = 15$ and state T ;
 2. substitute $n = 25$ and state T ;
 3. the person running the fete claims the stall took exactly \$100 on Saturday. Show, using arithmetic on the formula, why that claim cannot be true.
-

Energy flow diagrams: where the energy goes

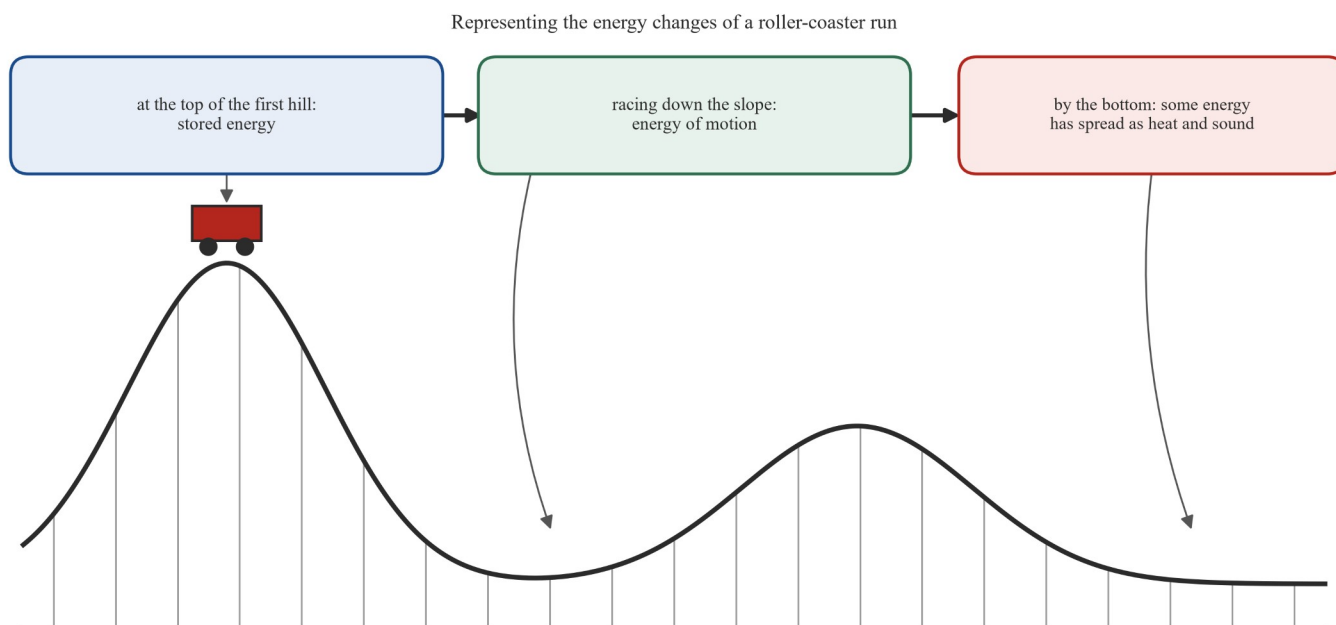
Plug in an old-style lamp and it gets warm — warmer than the light it gives would suggest. An **energy flow diagram** puts that observation on paper: one arrow in for the energy supplied, one arrow out for each place the energy ends up, and the width of each arrow standing for the share.



Energy flow diagram titled “An energy flow diagram — where the energy comes from and where it goes”. Left box “electrical energy from the power point” sends a thick arrow into a drawing of a glowing lamp; two arrows leave the lamp: a very wide arrow to a red box “heat energy (the lamp warms the room)” labelled “most of the energy”, and a thin arrow to an amber box “light energy (the lamp lights the room)” labelled “some of the energy”. Caption: “Wider arrow = bigger share of the energy. The total going out equals the total coming in — energy is never lost, only spread”.

Two rules govern the diagram. **Wider arrow, bigger share** — the lamp sends most of its energy to heating the room and a smaller share to light, so the heat arrow is drawn much wider. And **what goes out equals what comes in** — energy is never lost, only spread; the two out-arrows together carry exactly the one in-arrow. The diagram’s strength is that it makes a hidden truth visible: this lamp’s real job is light, yet most of what it takes becomes heat. Its limit is honesty about shares: the arrows say *most* and *some*, not exact numbers. Putting exact numbers on energy flows and asking how efficient a system is is Chapter 16’s work (16A names the energy forms precisely, 16B analyses efficiency) — here the diagram is qualitative, and that is its job.

The roller-coaster case from the elaboration shows the diagram as a story in three moments.



The cart at three moments — the arrows say what is changing into what, not how much

Diagram titled “Representing the energy changes of a roller-coaster run”. A roller-coaster track with a tall first hill and a lower second hill, a red cart at the top of the first hill, and three stage boxes joined by arrows above: “at the top of the first hill: stored energy” pointing down at the cart on the first hill; “racing down the slope: energy of motion” pointing at the dip after the first hill; “by the bottom: some energy has spread as heat and sound” pointing at the run-out after the lower second hill. Caption: “The cart at three moments — the arrows say what is changing into what, not how much”.

Read the picture like a scientist: at the top of the first hill the cart’s energy is stored (Chapter 16 will call energy of position *potential*); racing down, it is mostly energy of motion (*kinetic*, in Chapter 16’s words); and by the bottom, some has spread as heat and sound — which is why the second hill is drawn lower than the first. A coaster can never climb its own first hill again without being hauled up; some energy has spread beyond getting back. The representation’s strength is showing *what changes into what*; its limit, again, is that the arrows say nothing exact about *how much*.

Try it 5 — draw the flow (VC2S8I04.E05)

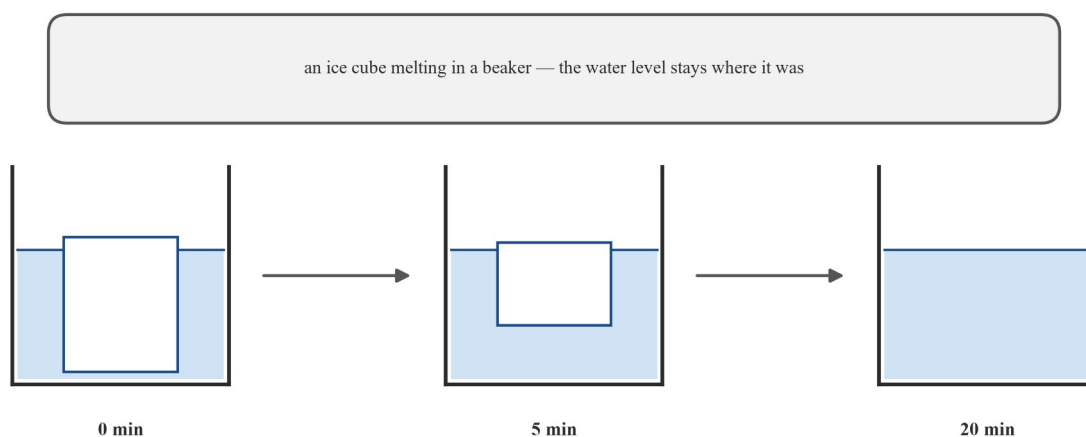
A hairdryer takes in electrical energy and delivers a hot, moving, noisy stream of air.

1. Draw an energy flow diagram for the hairdryer: one arrow in, three arrows out, each out-box named, and the arrows’ widths matching the shares you would expect (a hairdryer’s job is heat and moving air).
2. Under your diagram, write one sentence beginning “This diagram cannot show ...”.

Representing a change: a sequence of drawings

A photograph holds one instant. A change — melting, burning, growing — is a story across instants, and the representation for a story is a **sequence of drawings**: the same view, the same scale, frame after frame, with only time moving.

Representing a change: a sequence of drawings shows what one photograph cannot



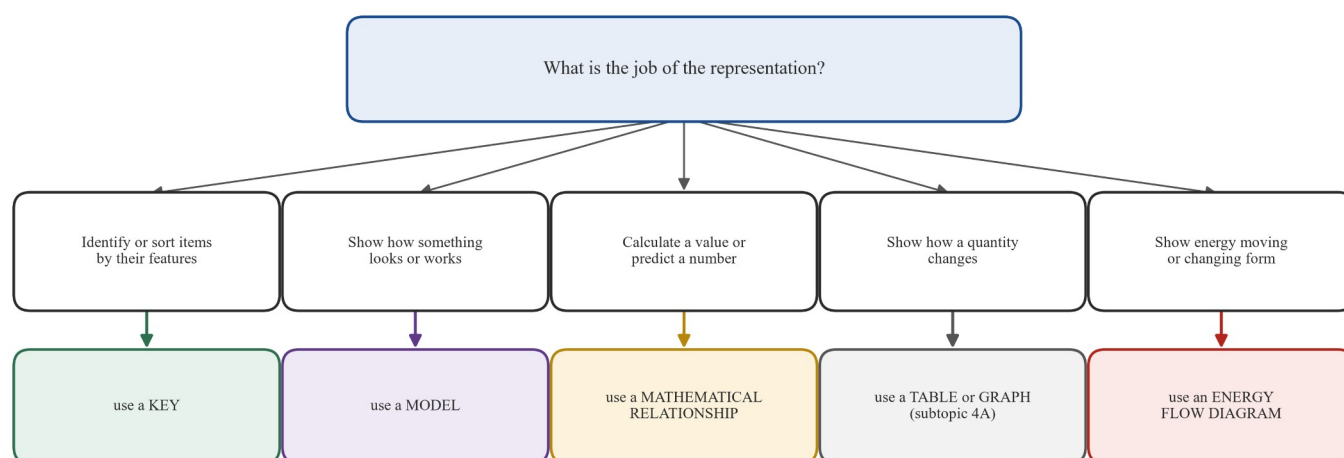
Each frame is the same scale and the same view — only time moves

Sequence diagram titled “Representing a change: a sequence of drawings shows what one photograph cannot”. Three identical beakers labelled 0 min, 5 min and 20 min, joined by arrows. Each holds water with the water line at the same height in all three frames; at 0 min a large ice cube floats with about nine-tenths below the water line, at 5 min a smaller cube floats the same way, and at 20 min only water remains at the unchanged level. Banner: “an ice cube melting in a beaker — the water level stays where it was”. Caption: “Each frame is the same scale and the same view — only time moves”.

The ice melts, the cube shrinks, and the water line stays where it was — floating ice melting changes the water level not at all, and the sequence shows that fact the way one photograph never could. Two rules make a sequence honest: **the same scale and the same view in every frame**, so that the only difference between frames is the change itself; and **frames far enough apart in time to show the change**, or the sequence says nothing. What the sequence hides is the *why* — the particle story of melting is 10A’s telling, and whether a change is physical or chemical is 11B’s question. Here the tool is the drawing of the change, not its explanation.

Choosing the representation

Six tools, one question: *what is the job?* The family chart at the top of the subtopic becomes a choosing chart.



Match the tool to the job — and be ready to say why that tool beats the others for this job

Decision chart titled “What is the job of the representation?” with five branches: “Identify or sort items by their features → use a KEY” (green); “Show how something looks or works → use a MODEL” (violet); “Calculate a value or predict a number → use a MATHEMATICAL RELATIONSHIP” (amber); “Show how a quantity changes → use a

TABLE or GRAPH (subtopic 4A) (grey); “Show energy moving or changing form → use an ENERGY FLOW DIAGRAM” (red). Caption: “Match the tool to the job — and be ready to say why that tool beats the others for this job”.

And because choosing well means knowing each tool’s price, the subtopic closes with its four headline representations laid side by side, strengths against limits.

Strengths and limits at a glance			
Representation	What it shows well	What it hides or gets wrong	Best when
Key	A fast way to name items; makes you look at features you can observe	Anything outside its set; items that fit two branches at once	You must identify an unknown item from a known set
Physical model	Size, shape and parts — you can walk around it and hand it around	The real size, weight and strength; how the real thing behaves	The real thing is too big, too small, too far away or too dangerous
Drawing or diagram	The steps of a process; where energy or material goes	Depth and real size — unless the drawing says it is to scale	You must show a change, a flow or a sequence
Mathematical relationship	Exact values; a prediction for any case inside the pattern	Anything the pattern leaves out — and why things happen	You must calculate, predict or check an answer

Summary table titled “Strengths and limits at a glance” with four rows — Key, Physical model, Drawing or diagram, Mathematical relationship — and three columns each: “What it shows well” (green), “What it hides or gets wrong” (red), and “Best when” (amber). Key: fast naming by observable features / anything outside its set, items that fit two branches at once / identifying an unknown item from a known set. Physical model: size, shape and parts you can handle / the real size, weight and strength, how the real thing behaves / the real thing is too big, too small, too far away or too dangerous. Drawing or diagram: steps of a process, where energy or material goes / depth and real size, unless it says it is to scale / showing a change, a flow or a sequence. Mathematical relationship: exact values, a prediction for any case inside the pattern / anything the pattern leaves out, and why things happen / calculating, predicting or checking an answer.

Read the red column as the price of the green one. A key buys fast naming and pays with blindness outside its set. A model buys a handleable stand-in and pays with the real thing’s strength and behaviour. A diagram buys the flow of a process and pays with depth and true size. A formula buys every case in the pattern and pays with everything the pattern leaves out — including *why*. That is the discipline this subtopic leaves you with: never take a representation on trust; ask what it shows well, name what it hides, and choose it — or reject it — on the answer.

Worked examples

Example 1 (scaffolded) — build a dichotomous key for four leaves

Four leaves are collected in the school grounds (the elaboration’s own context). Their observable features: leaf P is broad with a smooth edge; leaf Q is broad with a toothed edge; leaf R is long and narrow with a smooth edge; leaf S is long and narrow with a toothed edge. Build a dichotomous key that names each leaf.

Working	Comment
Question 1 splits on shape: 1a broad and flat ... go to 2 · 1b long and narrow ... go to 3.	First question uses a feature you can observe, and offers exactly two answers; it divides the set two-and-two.
Question 2 splits the broad leaves on edge: 2a edge smooth ... leaf P · 2b edge toothed ... leaf Q.	Each branch of question 1 gets its own follow-up question.
Question 3 splits the narrow leaves on edge: 3a edge	Same feature as question 2, asked of the other half of the

Working	Comment
smooth ... leaf R · 3b edge toothed ... leaf S.	set.
Test: $P \rightarrow 1a, 2a$; $Q \rightarrow 1a, 2b$; $R \rightarrow 1b, 3a$; $S \rightarrow 1b, 3b$.	Designing and testing are one job (VC2M8SP04): walk every item through before the key is trusted.
Four items, four leaves, no sharing.	

Example 2 (scaffolded) — substitute into the sizzle formula

Use $T = 20 + 3n$. Find T when $n = 15$, and find T when $n = 40$, then check one answer against the graph form of the relationship.

Working	Comment
$n = 15$: $T = 20 + 3 \times 15 = 20 + 45 = 65$.	Substitute first, then multiply before adding — the order the calculation needs.
$n = 40$: $T = 20 + 3 \times 40 = 20 + 120 = 140$.	The same three steps for any case in the pattern.
Check $n = 40$ on the graph: the point (40, 140) sits on the dashed line of the rule.	Reading one case back from a second form of the same relationship is the check habit from 4A.
Sense check: 40 sausages at \$3 is \$120, plus the \$20 stall — \$140 is reasonable.	The formula does not check sense; you do — estimating first is the checking habit.

Example 3 — weigh a model: keeps and loses

A class represents the same school garden three ways: a 1:50 cardboard scale model, a drawn plan on paper, and a photo taken from the same corner on the first day of each week of a term. Name one strength and one limit of each.

The scale model keeps proportions and parts you can point at — a strength when the question is *where could a new garden bed go?* — and loses true size and anything that changes, since cardboard does not grow. The drawn plan keeps positions and can carry a scale note and labels, and loses height entirely: a flat plan never says the lemon tree is two metres tall. The photo sequence keeps real change across the term, exactly as a sequence of drawings tries to, and loses the why — the photos show the beans climbing but not what fed them. Three representations, three jobs; no one of them is *the* garden.

Example 4 — choose and defend the representation

Two jobs at the fete. Job A: the people running the fete want to know, before the day, how much money the stall would take for *any* number of sausages. Job B: the lost-property box now holds forty mixed pens, pencils, rulers and erasers, and each item must be handed back to a named owner by its features. Choose a representation for each job and defend the choice with one strength of your tool and one limit of a rejected alternative.

Job A takes the mathematical relationship $T = 20 + 3n$: its strength is a value for any case in the pattern without running the stall forty times, and the rejected alternative — a table — keeps only the cases you thought to write down. Job B takes a key: its strength is fast, observable, yes–no naming for each of the forty items, and the rejected alternative — a model or a diagram — sorts nothing. The defence matters as much as the choice: naming what the rejected tool would have hidden is the evidence that the choice was made, not guessed.

Practice questions

Q1 (scaffolded). Using the couplet form of the stationery key, write the path for the paperclip as a list of couplet choices, and state its leaf.

Q2 (scaffolded). A key must sort four shapes: a big square, a small square, a big circle and a small circle. The first couplet is given: *1a the shape has straight sides ... go to 2 · 1b the shape is round ... go to 3*. Write couplets 2 and 3 so that each shape reaches its own leaf.

Q3 (scaffolded). The aquarium formula is $V = l \times w \times h$. Substitute $l = 50$ cm, $w = 20$ cm and $h = 30$ cm, calculate V in cm^3 , and convert your answer to litres.

Q4 (scaffolded). On the 1:100 cardboard hall model, the door measures 2 cm. Work backwards through the scale to state the real door's height in metres, showing the conversion.

Q5 (scaffolded). Match each job to the representation that best answers it — *key, model, mathematical relationship, energy flow diagram, or table or graph (4A)*:

1. predict the fete takings for 60 sausages;
2. name an unknown leaf collected on the school oval, from a known set of six;
3. show where a toaster's energy ends up;
4. display twenty measured bounce heights to see their spread;
5. stand in for Earth when explaining day and night.

Q6 (scaffolded). The lamp's energy flow diagram shows a wide heat arrow and a narrow light arrow. State the two rules of energy flow diagrams that fix the arrows' widths and their total.

Q7. Four items sit in a tray: a steel spoon, a wooden spoon, a steel key and a wooden ruler. Build a dichotomous key that gives each item its own leaf, writing it as numbered couplets. (2 marks)

Q8. A student says a key built for six items can identify *any* object brought to the table. Use the steel-key failure to explain in two sentences why the claim is false. (2 marks)

Q9. The red-pen and blue-pen failure shows a key separating items only by the features its questions use. State one feature the stationery key uses, and one observable feature of the pens it could have used but does not. (2 marks)

Q10. A globe shows Earth's shape, tilt and the position of countries well. Name two things a globe cannot show, and for each say whether a different representation on this subtopic's family chart could show it better. (2 marks)

Q11. A torch running on a battery gives light and gets slightly warm. Draw an energy flow diagram for the torch: label the in-arrow and both out-arrows, and make the widths match the shares. Then write the one sentence beginning "This diagram cannot show ...". (3 marks)

Q12. The people running the fete must choose between a table of T values for $n = 0, 10, 20, 30, 40$ and the formula $T = 20 + 3n$ to brief next year's committee. Choose one and defend it with one strength of your choice and one limit of the other. (2 marks)

Q13. A student photographs an ice cube in a beaker once, at 0 minutes, and says the single photo represents the melting. State two things a three-frame sequence (0, 5, 20 minutes) shows that the single photo cannot, and the two rules the frames must keep to be honest. (3 marks)

Q14. A student's key for the four shapes of Try it 2 contains this couplet: *2a the shape is red ... red circle · 2b the shape is not red ... go to 3*. A blue square and a blue circle both reach couplet 3. Explain whether this is a fault in the key, and what couplet 3 must ask for the key to work. (3 marks)

Answers

Q1. 1b, 3b, 4b, 5b → paperclip.

Q2. 2a the shape is big ... big square · 2b the shape is small ... small square · 3a the shape is big ... big circle · 3b the shape is small ... small circle. (Any other observable two-way split that gives four own leaves is acceptable.)

Q3. $V = 50 \times 20 \times 30 = 30\,000 \text{ cm}^3 = 30 \text{ L}$.

Q4. $2 \text{ cm} \times 100 = 200 \text{ cm} = 2 \text{ m}$.

Q5. 1 mathematical relationship · 2 key · 3 energy flow diagram · 4 table or graph · 5 model.

Q6. Wider arrow = bigger share of the energy; and the total going out equals the total coming in (energy is never lost, only spread).

Q7. Any working key; for example: 1a made mainly of metal ... go to 2 · 1b made mainly of wood ... go to 3 · 2a used for eating ... steel spoon · 2b used for opening locks ... steel key · 3a used for measuring length ... wooden ruler · 3b used for stirring and serving ... wooden spoon.

Q8. At couplet 5 neither branch is true of the steel key, so the walk stops — a key has leaves only for the set it was built from, and handed a stranger it should stop rather than guess.

Q9. Used: what the item is used for (or what it is made of, or whether it measures length). Not used but observable: colour (or length in cm, or mass).

Q10. Any two keeps/loses pairs with a fairer tool named; for example: a globe cannot show the real size of Earth (no classroom stand-in can — a scale note is the best a model does), and cannot show flood water moving over land, which a virtual simulation can run again and again.

Q11. In: electrical energy from the battery. Out: light (wide arrow — the torch's job) and heat (narrow arrow — it only gets slightly warm). Sentence: any true limit, e.g. "This diagram cannot show how much energy goes each way, only which share is bigger."

Q12. Any defended choice; for example: the formula, because it answers for any n , while the table keeps only the five cases written down. (Choosing the table is creditable if defended: the table keeps exact values with no calculation, while the formula hands the committee a letter to substitute.)

Q13. The sequence shows the cube shrinking *and* the water line holding its place across time — the change itself, which one instant cannot hold. Rules: the same scale and the same view in every frame.

Q14. Not a fault: couplet 2 splits red from not-red, and the two blue shapes *should* travel together until a later couplet separates them. Couplet 3 must ask a question the two blues answer in different ways — round or straight-sided: 3a round ... blue circle · 3b straight-sided ... blue square.

Fully-worked solutions

Q1. The paperclip is not for writing or drawing (1b), not for measuring length (3b), does not rub out pencil marks (4b), and is not metal with blades that cut — at couplet 5 it takes the "no" branch: path 1b, 3b, 4b, 5b, leaf *paperclip*. One mark for the correct path, one for the leaf.

Q2. Couplet 2 serves the straight-sided shapes: 2a the shape is big ... big square; 2b the shape is small ... small square. Couplet 3 serves the round shapes: 3a the shape is big ... big circle; 3b the shape is small ... small circle. Test: big square 1a, 2a; small square 1a, 2b; big circle 1b, 3a; small circle 1b, 3b — four items, four leaves, no sharing, and every question two-answer and observable. One mark per correct couplet.

Q3. Substitute: $V = 50 \times 20 \times 30$. $50 \times 20 = 1\,000$; $1\,000 \times 30 = 30\,000$, so $V = 30\,000 \text{ cm}^3$. The maintained Level 6 conversion says $1\,000 \text{ cm}^3 = 1 \text{ L}$, so $30\,000 \text{ cm}^3 = 30 \text{ L}$. One mark for the correct substitution and product, one for the conversion.

Q4. The model shrinks every length 100 times, so the real door is the model door grown 100 times: $2\text{ cm} \times 100 = 200\text{ cm}$. Converting, $200\text{ cm} = 2\text{ m}$ — a sensible door height, which is itself the sense check. One mark for the $\times 100$ step, one for the conversion to metres.

Q5. 1 A prediction for any number in the pattern is the formula's one unmatched strength $\rightarrow$ mathematical relationship. 2 Naming an unknown item from a known set by observable features is the key's home job $\rightarrow$ key. 3 Where energy ends up, with shares, is the energy flow diagram. 4 A spread of twenty values of one quantity is 4A's dot-plot or stem-and-leaf territory $\rightarrow$ table or graph. 5 Earth is too big to bring in, so a stand-in that keeps shape and tilt $\rightarrow$ model.

Q6. Rule one: the wider the arrow, the bigger the share of the energy going that way — so the heat arrow is drawn wider than the light arrow because most of the lamp's energy becomes heat. Rule two: the total going out equals the total coming in — energy is never lost, only spread — so the two out-arrows together must carry the whole in-arrow. One mark per rule.

Q7. A working model answer: 1a made mainly of metal ... go to 2 · 1b made mainly of wood ... go to 3 · 2a used for eating ... steel spoon · 2b used for opening locks ... steel key · 3a used for measuring length ... wooden ruler · 3b used for stirring and serving ... wooden spoon. Test: steel spoon 1a, 2a; steel key 1a, 2b; wooden ruler 1b, 3a; wooden spoon 1b, 3b — four own leaves. One mark for a key in which every item reaches its own leaf by two-answer, observable questions; one for the questions being observable and two-way (a three-answer question, or a question about what the owner thinks, loses the second mark).

Q8. The steel key walks 1b, 3b, 4b and at couplet 5 neither branch is true — it does not cut and it does not hold paper — so the key stops. That stopping is the claim's counter-example: a key names members of the set its questions were built from, and an item outside that set finds no leaf, so the key identifies its own set, not *any* object. One mark for the correct trace-and-stop, one for the general point.

Q9. A feature the key uses: any of “used for writing or drawing”, “made mainly of wood”, “used for measuring length”, “rubs out pencil marks”, “metal with blades that cut”. An observable feature of the pens it does not use: colour is the example in front of you — red and blue walk the same path — or length, or mass. One mark each.

Q10. A creditable pair: a globe cannot show Earth's true size or the real materials of land and sea — every physical model drops real size, weight and strength — and no classroom representation fixes true size, only a scale note makes the shrinkage honest. A globe also cannot show water moving over land as a flood does, and a virtual simulation shows that better, because it can run the process again and again, faster or slower. One mark per limit-with-fairer-tool (the second limit may honestly say “no representation in the family shows true size — a scale note is the honest fix”).

Q11. The in-arrow is electrical energy from the battery. The out-arrows are light, drawn wide because light is the torch's job and most of its useful share, and heat, drawn narrow because the torch only gets slightly warm. (The sound a torch makes is too small to matter, so two out-arrows are enough.) The sentence: any true limit — “This diagram cannot show how many joules go each way, only which share is bigger” — because arrow widths here carry *most/some*, not numbers; exact shares are Chapter 16's work. One mark for a correctly labelled diagram with matching widths, one for the width reasoning, one for a true cannot-show sentence.

Q12. Choosing the formula: its strength is a value for *any* n — next year's committee can ask about 60, 75 or 132 sausages and get an answer on the spot — while the table's limit is that it keeps only the five cases someone thought to write down. Choosing the table: its strength is exact values sitting there with no calculation demanded of the reader, while the formula's limit is that every reader must substitute and calculate, and a mis-substituted letter reads as a right answer. Either choice takes both marks if the strength and the limit are real and belong to the right tool.

Q13. The single photo holds one instant; the sequence shows the change — the cube shrinking frame by frame — and it shows the water line holding its place while the ice melts, a fact about time that no instant can carry. The honesty rules: every frame at the same scale, and every frame from the same view, so that the only difference between frames is time. One mark for each shown thing, one for both rules.

Q14. It is not a fault. Couplet 2's job is to split red from not-red; the blue square and the blue circle answer 2b the same way and *should* travel together to couplet 3 — that is how a dichotomous key works, exactly like the red and blue pens sharing a path in the stationery key. The fault would be a couplet 3 that cannot separate them, so couplet 3 must ask a feature the two blues answer in different ways: 3a the shape is round ... blue circle · 3b the shape has

straight sides ... blue square. Test: blue circle 2b, 3a; blue square 2b, 3b — every item at its own leaf. One mark for “not a fault, they should travel together”, one for the correct couplet 3, one for the test or a clear trace.

Sources

- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description VC2S8I04 and its elaborations, 2026. vcaa.vic.edu.au — retrieved 2026-08-21.
- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Mathematics*, VC2M7A01, VC2M7SP04 and VC2M8SP04 (the D11 interlocks), 2026 — retrieved 2026-08-21.

All numerical series in the figures and questions (the sausage-sizzle relationship, the aquarium dimensions, the school-hall scale model, the stationery and shape and leaf keys, and the energy share arrows) are **simulated data and teaching examples for practice**, labelled as such where a figure carries them; they are teaching material, not measurements, and carry no source claim.

Elaboration context used: VC2S8I04.E01 (the three-kinds-of-model strengths-and-limits work), VC2S8I04.E02 (the pooled-stationery key and the schoolyard-leaves context), VC2S8I04.E03 (the sequence-of-drawings representation of a physical change), VC2S8I04.E04 (the key read as a sequence of steps and decisions) and VC2S8I04.E05 (the lamp and roller-coaster energy flow diagrams).

Teacher-facing note (not student text). 4B is the partner for the keys, models and mathematical relationships clause of VC2S8I04; tables and graphs are 4A’s († split delivery, D6), and the achievement-standard extract is quoted in full in 4A’s owner header. The scope ceiling is held: energy forms are named precisely and classed kinetic/potential only by forward reference to 16A, efficiency and Sankey analysis are 16B’s and never computed here, particle models of change are 10A/10B’s, physical-versus-chemical change is 11B’s, and using keys on organisms is 7B’s; the Level 6 unit conversion (VC2M6M01) is maintained, shown step by step, and not re-taught. No Aboriginal and Torres Strait Islander content is drawn on here: VC2S8I04 carries no such elaborations, and D10’s sourced treatments sit in the subtopics the TOC names.

Reading processed and secondary data for patterns, trends, relationships and anomalies

What we teach here — VC2S8I05 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8):

“information and processed data can be analysed to show patterns, trends and relationships, and to identify anomalies” **This subtopic owns the whole CD** (TOC §3): the analysis move itself — taking

information and processed data and reading it for patterns, trends, relationships and anomalies. Every other subtopic in this book collects, tables or graphs data; 4C is where the data gets *read*. **In our words:** data on its own is quiet — a table of numbers says nothing until somebody looks at it the right way. This subtopic teaches the looking. Four reading moves do most of the work: find the **pattern** (a shape that repeats), find the **trend** (the long direction), find the **relationship** (two quantities that change together), and catch the **anomaly** (the point that does not fit). And because a quick eye can be a sloppy eye, the fifth habit is

checking before believing: is that odd point a real finding or a recording slip, and is that dramatic graph really dramatic, or is it just a sneaky axis? **Achievement-standard extract served here (D13):** *“They analyse and connect data and information to identify and explain patterns, trends, relationships and anomalies.”* 4C is the owner of VC2S8I05, so the extract appears here in full; other subtopics cite it by reference to this header. **Elaborations drawn on:** VC2S8I05.E01 (tidal variations over the course of a

lunar cycle — our repeating-pattern case), VC2S8I05.E02 (secondary data on population change — the rabbit spread, the short-tailed shearwaters’ year and the southern right whales’ twenty winters), VC2S8I05.E03 (the drop-height-and-indentation relationship, analysed for causality) and

VC2S8I05.E04 (temperature rise from different proportions of the same chemicals — a relationship that is not a straight climb). All four elaborations are used here as contexts (D12), not as a checklist of content.

Scope notes: the scope ceiling is held. Graphs are read *in words, by shape* — gradient and lines of best fit are Years 9–10 maths (VC2M9A04, VC2M10ST02) and do not appear here. Averages and spreads belong to 4A; evaluating *how* data was collected belongs to 5A; the Moon–tide mechanism is 14B’s and the chemistry that explains the proportions result is kept for the chemistry chapters — here the tide and the chemistry are read as data, not explained. The D11 interlocks are *used, not taught*: reading axes draws on VC2M7A04/ VC2M7A05, and the sample-size caution draws on VC2M8ST03.

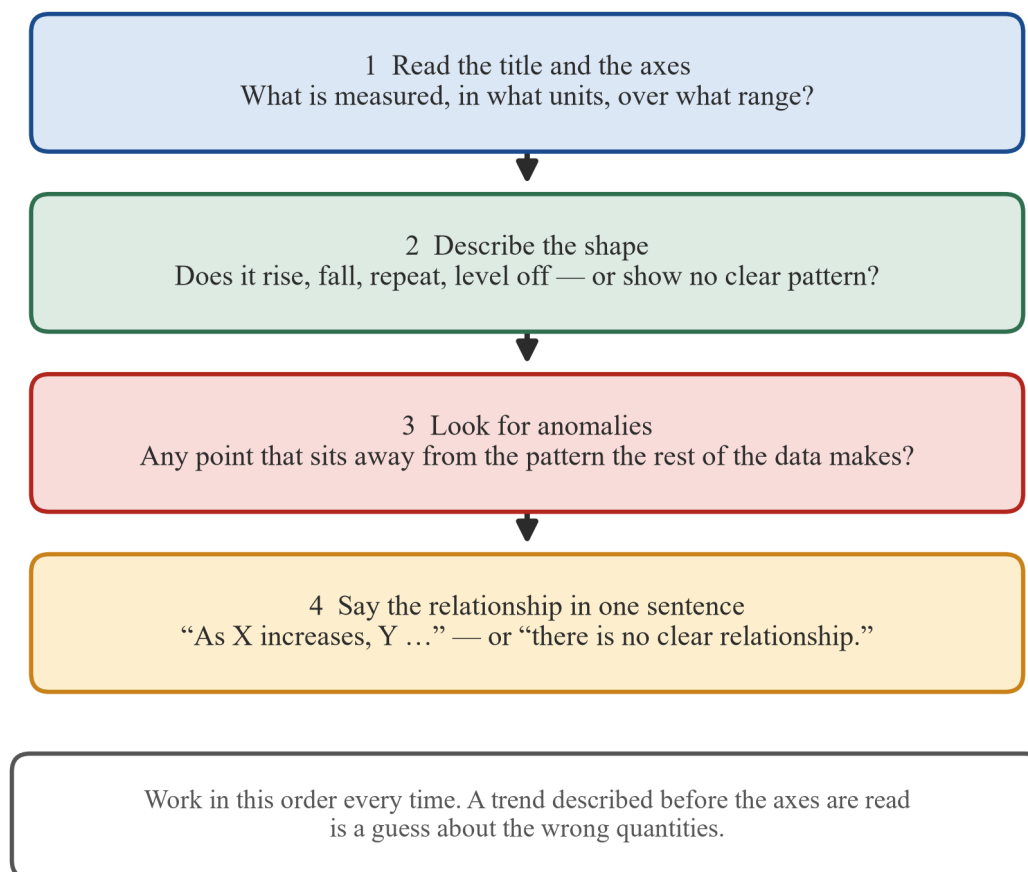
Word watch — *pattern, trend, relationship, anomaly, primary data, secondary data*. These six words are the working tools of this subtopic, so their meanings are fixed here. A **pattern** is a shape that repeats often enough that you could say what comes next. A **trend** is the long direction data travels across a stretch of time, even when individual points wobble up and down. A **relationship** is a link between two quantities — as one changes, the other changes in a regular way you can describe. An **anomaly** is a data point that sits away from the pattern the rest of the data makes. **Primary data** is data you or your class collected yourselves in your own investigation. **Secondary data** is data somebody else collected, and you are reading their record. The curriculum’s elaborations lean hard on secondary data — tide tables, sighting records, historical counts — because it lets you analyse things no school could ever measure.

Theory

The four reading moves

Analysis is not staring at a graph and hoping. It is a routine — the same four moves, in the same order, every time data goes in front of you.

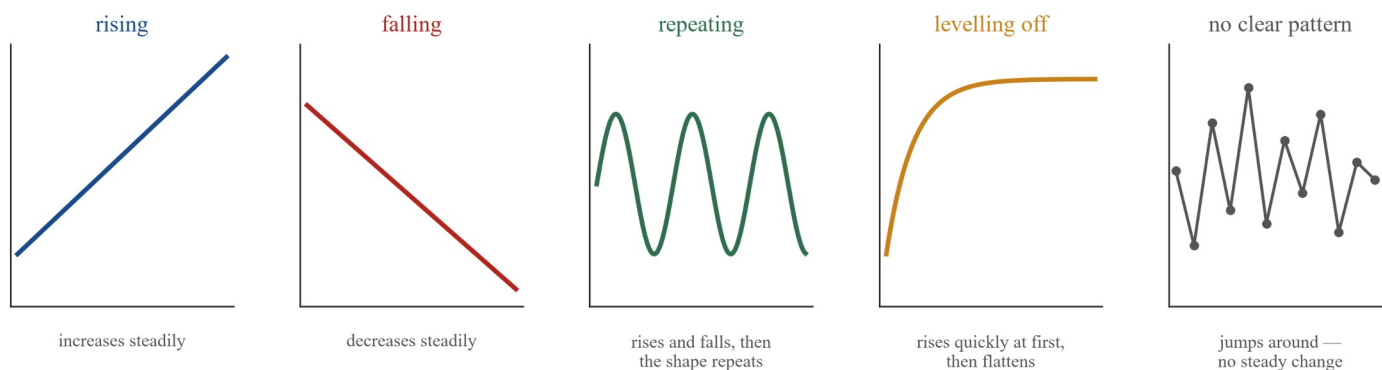
Reading any graph or table — the four moves



Flow chart titled “Reading any graph or table — the four moves”, with four steps joined by downward arrows: 1 Read the title and the axes — what is measured, in what units, over what range; 2 Describe the shape — does it rise, fall, repeat, level off, or show no clear pattern; 3 Look for anomalies — any point that sits away from the pattern the rest of the data makes; 4 Say the relationship in one sentence — “As X increases, Y ...” or “there is no clear relationship”; a footer box warns to work in this order every time, because a trend described before the axes are read is a guess about the wrong quantities

Move 1 is the one students skip and regret. The title says what the data is about; the axes say what was measured, in what units, over what range. A reader who skips move 1 can describe a beautiful rising trend in the wrong units about the wrong quantity — the shape was right and the story was nonsense. Moves 2 and 3 need a shared vocabulary, because “it goes up and then it does that thing” is not analysis. The shapes a data set can make have names:

Words for the shape a data set can make — the vocabulary of this subtopic



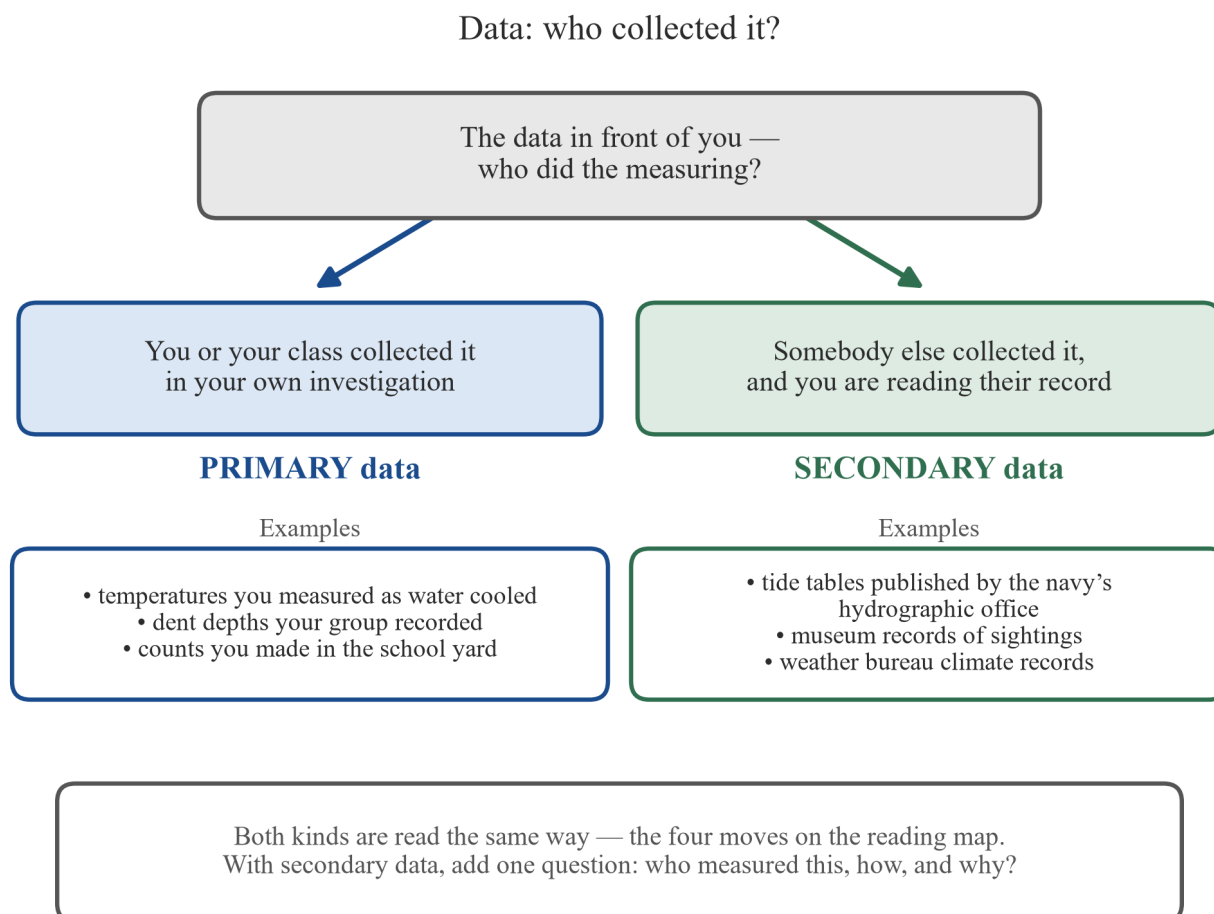
Five small graphs under the title “Words for the shape a data set can make — the vocabulary of this subtopic”, one panel for each shape word: rising (increases steadily), falling (decreases steadily), repeating (rises and falls, then the

shape repeats), levelling off (rises quickly at first, then flattens), and no clear pattern (jumps around with no steady change)

And “no clear pattern” is a finding, not a failure. Data that jumps around with no steady change is telling you that the two things are not linked in any simple way — that is move 4 done well, not move 2 done badly.

Primary and secondary data

Before the moves, one question about the data itself: who collected it?

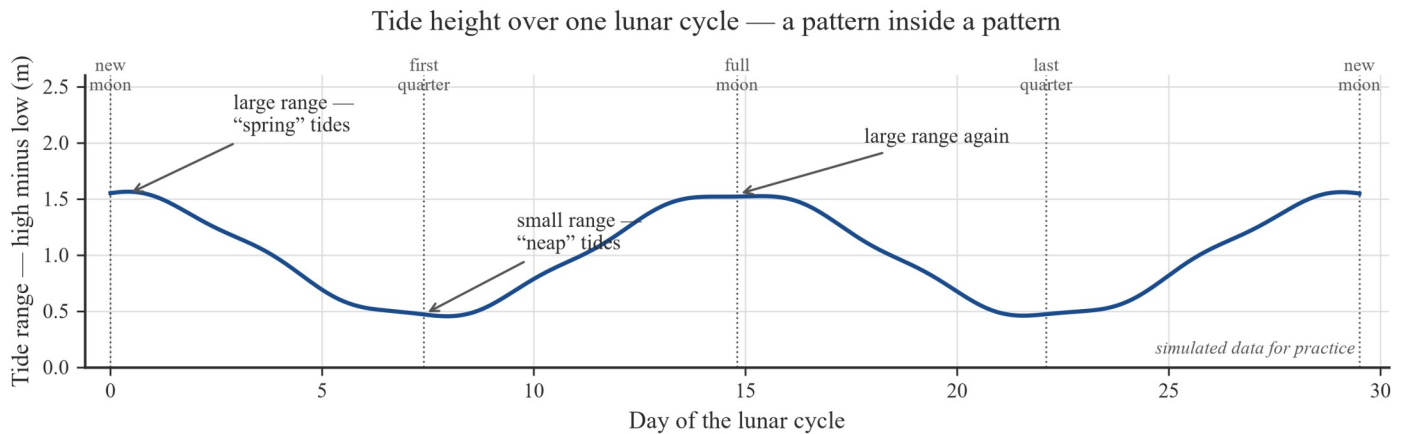


Decision tree titled “Data: who collected it?” splitting “the data in front of you” into two branches: PRIMARY data — you or your class collected it in your own investigation, with examples of temperatures you measured as water cooled, dent depths your group recorded, and counts you made in the school yard; and SECONDARY data — somebody else collected it and you are reading their record, with examples of published tide tables, museum records of sightings, and weather bureau climate records; a footer notes that both kinds are read the same way with the four moves, and that secondary data adds one extra question: who measured this, how, and why?

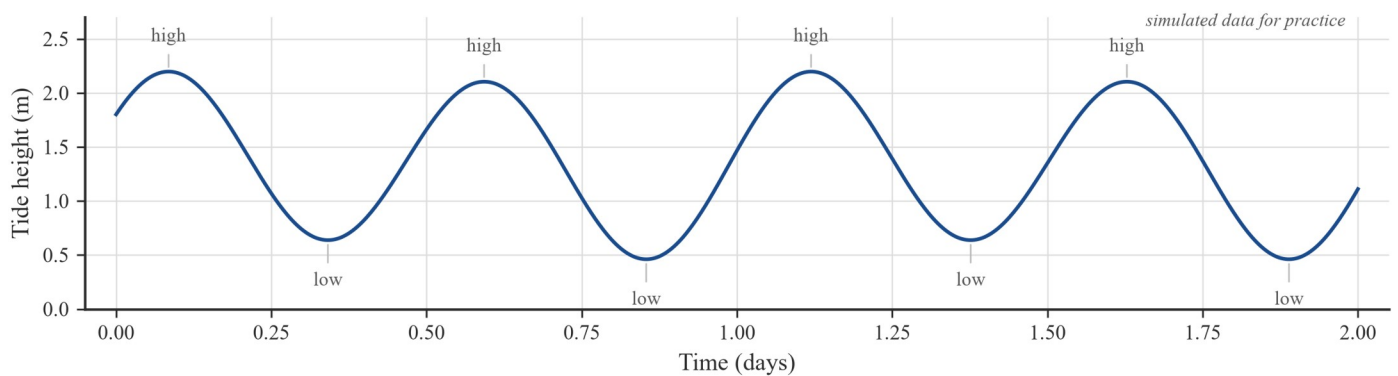
Most of the science in this subtopic runs on **secondary data**, and that is deliberate (VC2S8I05.E01 and .E02 both name it). No classroom can watch a rabbit population cross a continent, count whales for twenty winters, or sit on a headland for a lunar cycle with a ruler. Other people did those measurements, and their records are data too — processed data, often, meaning the raw measurements have already been cleaned up, totalled or averaged into a form you can read. The four moves work the same way on both kinds. The only addition for secondary data is the extra question in the footer — *who measured this, how, and why?* — and the deep answer to that question (how much to trust a method and a source) is 5A’s business; here the question is asked, and the reading goes on.

Pattern 1 — the tide and the lunar cycle (VC2S8I05.E01)

Tide records are the curriculum’s own case of a pattern in secondary data, and the pattern turns out to be a pattern inside a pattern.



The big swing repeats about every 14–15 days, and the whole pattern repeats after one lunar cycle (about 29.5 days).



Zoomed in: the height rises and falls about twice each day.

Two-panel graph titled “Tide height over one lunar cycle — a pattern inside a pattern”, labelled “simulated data for practice”. Top panel: tide range (high minus low, in metres) across the 29.5 days of a lunar cycle, with large “spring” ranges at new and full moon and small “neap” ranges at first and last quarter, the big swing repeating about every 14–15 days and the whole shape repeating after one lunar cycle. Bottom panel: the same record zoomed to two days, the height rising and falling about twice each day, with every high and low marked

Read with the four moves. Move 1: the top panel is tide *range* — high minus low each day, in metres — across one **lunar cycle**, the roughly 29.5-day cycle of Moon shapes; the bottom panel is tide *height* over two days. Move 2, the shape: the bottom panel rises and falls about twice a day — a daily pattern — and the top panel shows the size of that daily swing itself rising and falling on a 14–15 day repeat, largest at new and full moon (the “spring” tides) and smallest at the quarter moons (the “neap” tides). Move 3: no point sits away from the shape — the wobbles are *part* of the shape. Move 4, the one-sentence read: *the daily tide range grows and shrinks on a 14–15 day repeat that keeps step with the Moon’s shape*.

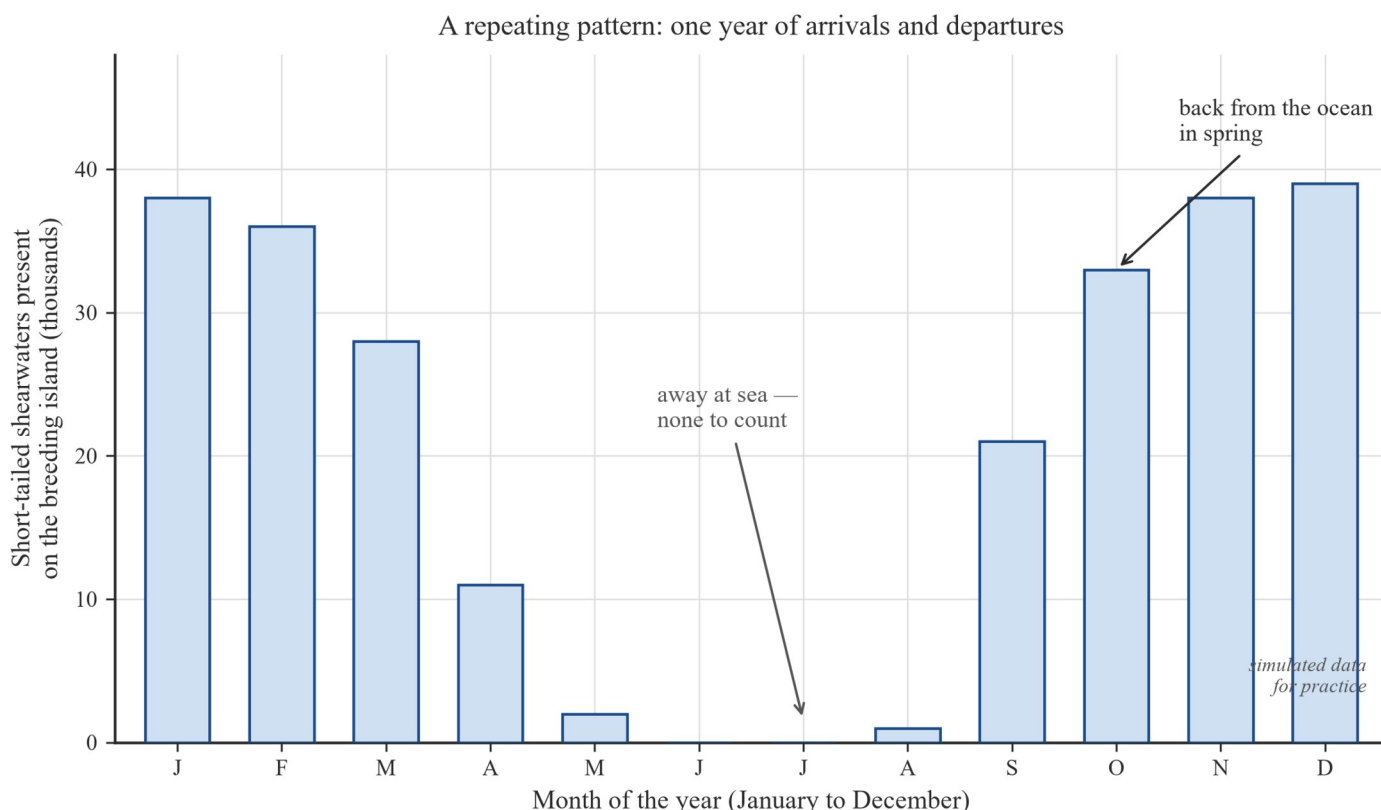
Notice what this subtopic does **not** do with that sentence: it does not say *why* the Moon and the tides keep step. The mechanism is a gravitational story belonging to 14B. Here, the tide data is a pattern to be identified and explained *as a pattern* — which is exactly the work VC2S8I05 sets.

Try it 1 — read the tide pattern (VC2S8I05.E01)

1. At which two Moon shapes is the daily tide range largest, and at which two is it smallest?
2. Roughly how many days pass from one spring (largest-range) stretch to the next?
3. In the two-day panel, how many highs and how many lows does each day show?
4. Which of the four shape words — rising, falling, repeating, levelling off — names the shape of the top panel?

Pattern 2 — a year on the breeding island (VC2S8I05.E02)

Short-tailed shearwaters spend part of each year at ocean and part on their breeding islands. Counting them on the island month by month is secondary data of the kind VC2S8I05.E02 points to, and the shape it makes is the cleanest kind of pattern: a repeat.



Bar chart titled “A repeating pattern: one year of arrivals and departures”, labelled “simulated data for practice”, showing thousands of short-tailed shearwaters present on the breeding island in each month from January to December: high, around 36–39 thousand, from November to March; falling through autumn to zero in June and July while the birds are away at sea; and climbing back through spring as they return from the ocean

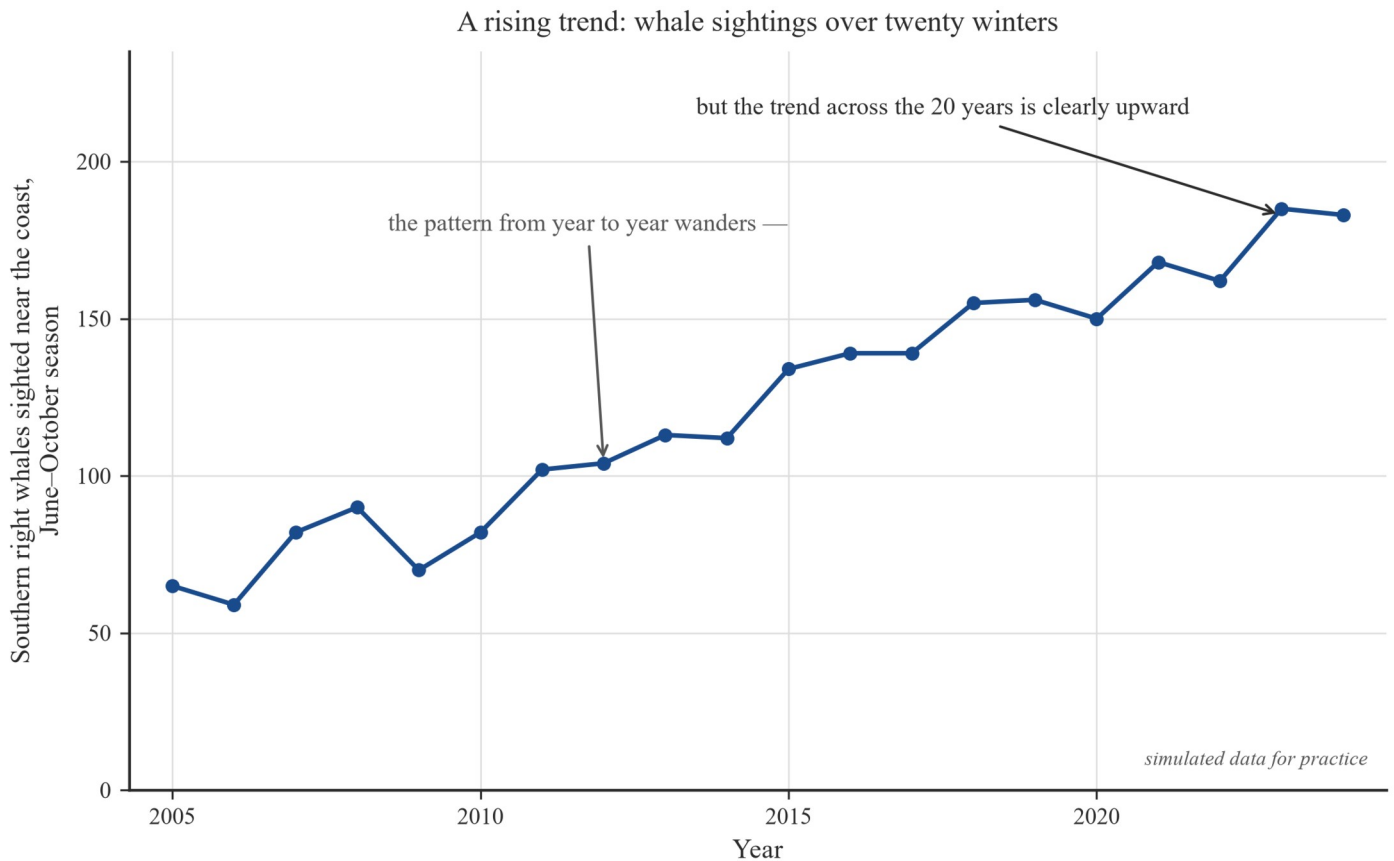
Move 2 says: high from November to March, falling through autumn, none to count in June and July, back in spring — and the same shape every year. The zero months are the teaching point. A first reading can call June and July *anomalies*: points sitting away from the pattern. They are not. An anomaly sits away from the shape the rest of the data makes; here the empty winter *is part of the shape*. The birds are not missing data — they are at sea, being shearwaters. A pattern can include a zero, and the test for an anomaly is “does this point break a shape that repeats?”, not “is this number small?”

Try it 2 — the shearwater year (VC2S8I05.E02)

1. Describe the pattern across the year in two sentences, using at least two of the shape words.
2. In which months would a visitor to the island find almost no birds, and where are the birds instead?
3. Without seeing next year’s counts, say roughly what the December bar will look like, and give the reason your guess is allowed.

Trend — twenty winters of whale sightings (VC2S8I05.E02)

Southern right whales are sighted off the southern coast each winter season. Twenty years of sighting records, added up season by season, is secondary data with a different shape from the shearwater year: it does not repeat — it *travels*.



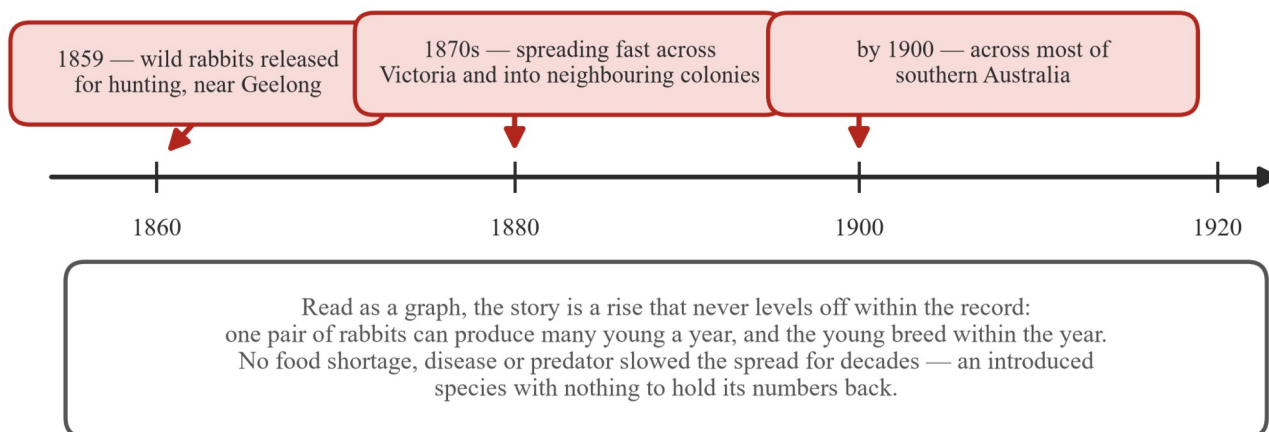
Line graph titled “A rising trend: whale sightings over twenty winters”, labelled “simulated data for practice”, plotting southern right whales sighted near the coast each June–October season from 2005 to 2024; the points wobble from year to year but climb overall from about 60 in 2005 to about 190 in 2024, labelled “the pattern from year to year wanders — but the trend across the 20 years is clearly upward”

This is the word **trend** doing its proper work. The year-to-year pattern wanders — a count falls here, jumps there — and none of the individual wobbles is an anomaly; with this much natural variation, one up-and-down year is just variation (a point 4A makes about spread). But step back and the long direction is plain: *sightings rise across the twenty years, from about 60 a season to about 190*. Trend is the direction you see when you stop chasing every wobble. The pattern/trend difference in one line: a **pattern** repeats, so you can say what comes next; a **trend** travels, so you can say which way things are going.

Secondary data from the history books — the rabbit spread (VC2S8I05.E02)

Not all secondary data is a table of numbers. The historical record of the rabbit in Australia is secondary data too — counts, reports and maps collected by people long dead — and VC2S8I05.E02 names rabbits among the population changes to examine.

A population out of control: the rabbit spread, told as a timeline



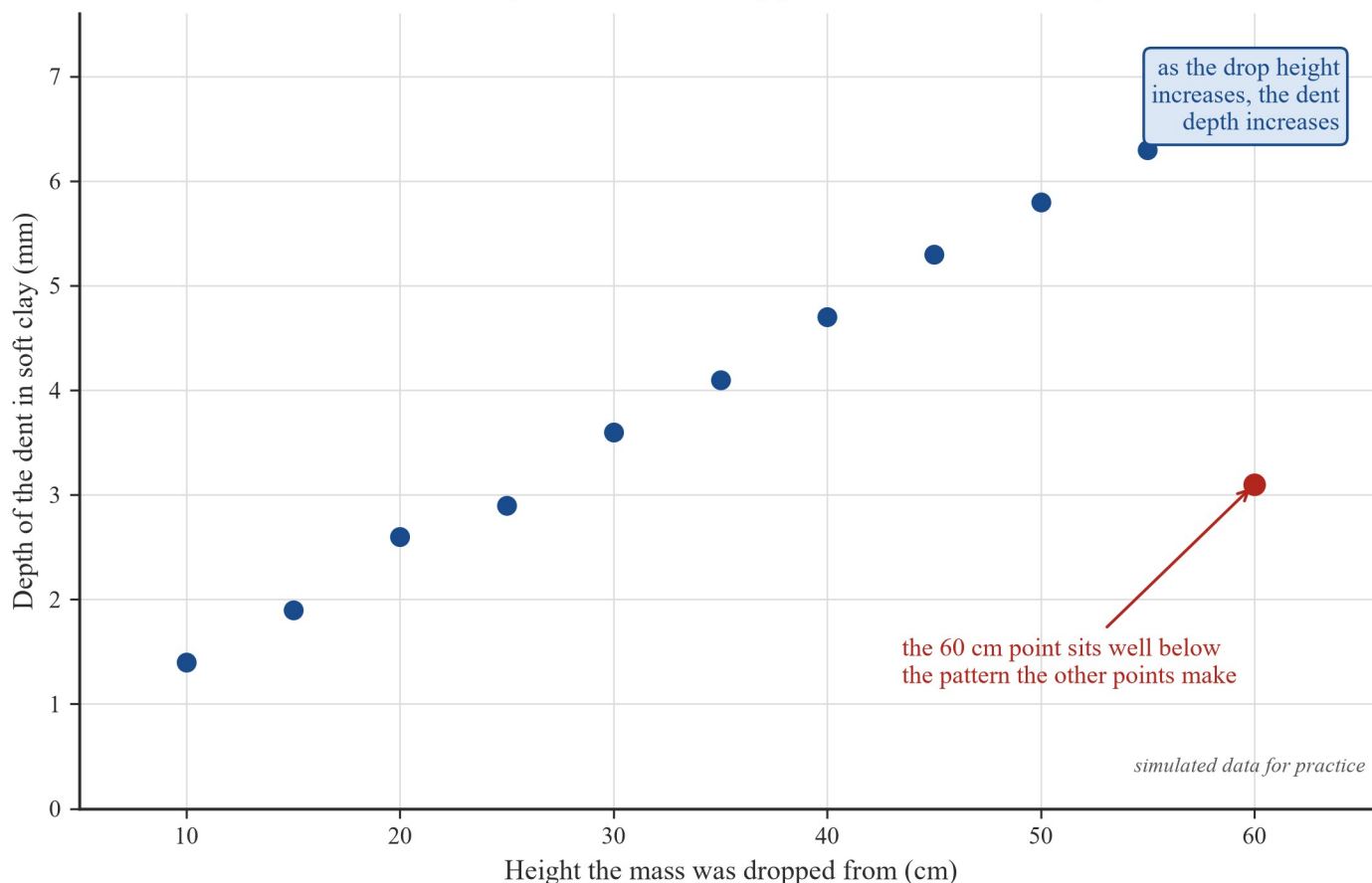
Timeline titled “A population out of control: the rabbit spread, told as a timeline”, with a horizontal time arrow marked 1860, 1880, 1900 and 1920 and three events above it: 1859 — wild rabbits released for hunting, near Geelong; 1870s — spreading fast across Victoria and into neighbouring colonies; by 1900 — across most of southern Australia; a note below reads the story as a rise that never levels off within the record, because one pair of rabbits can produce many young in a year and the young breed within the year

Read as a shape, the record is a rise that never levels off within the forty years shown — an introduced species with plenty of food and nothing to hold its numbers back, so the population change is a one-way climb. Set it beside the shearwater year and the difference is the lesson: the shearwaters *repeat*, the rabbits *climb*. One is a pattern, the other a trend, and the same four moves pick that difference up from the shape alone.

Relationship — dropping from higher (VC2S8I05.E03)

The third move points one quantity at another. The curriculum’s own case (VC2S8I05.E03) is a mass dropped into soft clay from different heights, with the dent depth measured each time: “*Dropping a mass from a greater height produces a larger indentation.*” Here is a class version of that data.

A relationship in a scatter: ten tidy points — and one anomaly



Scatter plot titled “A relationship in a scatter: ten tidy points — and one anomaly”, labelled “simulated data for practice”, plotting dent depth in soft clay (millimetres) against the height the mass was dropped from (centimetres); ten blue points climb steadily from 1.4 mm at 10 cm to 6.3 mm at 55 cm, with the note “as the drop height increases, the dent depth increases”, while one red point at 60 cm and 3.1 mm sits well below the pattern the other points make

Moves 1–2: dent depth in millimetres against drop height in centimetres, and the ten blue points rise steadily. Move 4 writes itself: *as the drop height increases, the dent depth increases*. Two quantities changing together in a regular way is a **relationship**, and this one is the kind VC2S8I05.E03 calls *correlational* — the data shows the togetherness. Then the elaboration’s second step: analyse the relationship for **causality**. Does the greater height *cause* the deeper dent, or is the togetherness a coincidence? Here the cause story is strong, and 2A’s checks say why: the drop height was set by the experimenter, so it comes first; it was the only thing changed, with the same mass and the same clay every drop; and there is a sensible story — a fall from higher arrives moving faster and hits harder. This is a relationship you can argue is causal. (The formal correlation/causation toolkit is 2A’s; 4C uses it on the way past.)

Move 3, though, has work to do first: the red point. At 60 cm — the *highest* drop — the dent is shallower than at 30 cm. That point sits a long way off the shape the other ten make. It is an **anomaly**, and what you do with it is the next lesson.

Try it 3 — trend or pattern? (VC2S8I05.E02)

1. Write the trend of the whale-sighting graph in one sentence, including roughly where it starts and roughly where it ends.
2. A student calls the whale graph a *pattern*. Using the repeat test, say why *trend* is the better word.
3. Read the rabbit timeline as a shape: which two shape words describe it, and which word would be wrong?

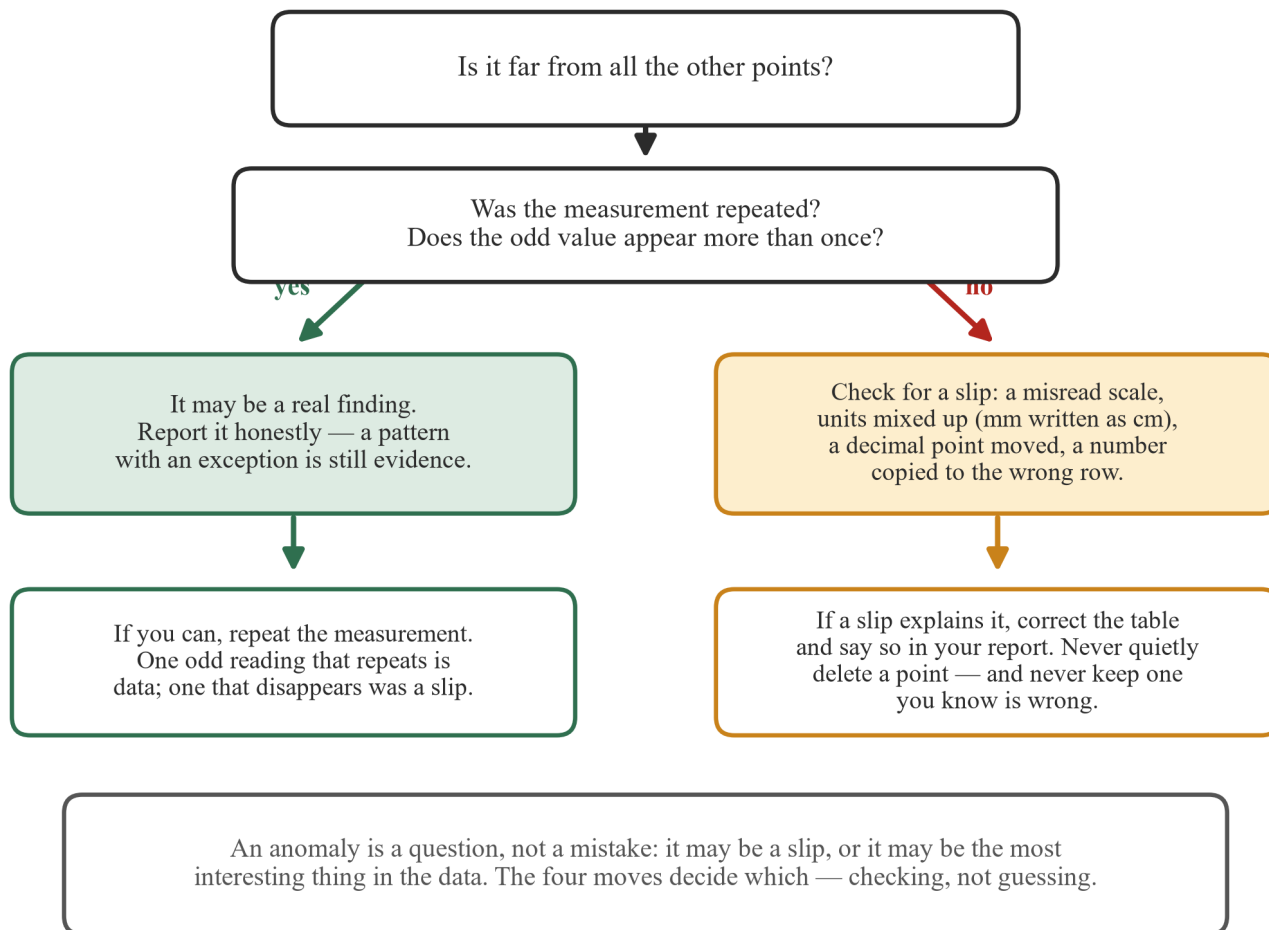
Try it 4 — describe the relationship (VC2S8I05.E03)

1. Write the drop-height data as one “As ... increases, ... increases” sentence.
2. Name the anomaly in the scatter, giving its drop height and its dent depth.
3. Give the two checks from 2A that make the causal story (higher drop → deeper dent) a strong one here.

Anomalies — check, don't guess

An anomaly is a question, not a mistake. Faced with the 60 cm point, there are two lazy errors: quietly delete it so the graph looks tidy, or keep it and pretend nothing is odd. Both bury information. The disciplined move is to *check*, and the checks are short.

A point sits away from the pattern — before you decide anything



Decision tree titled “A point sits away from the pattern — before you decide anything”. The first box asks whether the point is far from all the other points; the next asks whether the measurement was repeated and whether the odd value appears more than once. The yes branch leads to “it may be a real finding — report it honestly; a pattern with an exception is still evidence”, then “if you can, repeat the measurement; one odd reading that repeats is data; one that disappears was a slip”. The no branch leads to “check for a slip: a misread scale, units mixed up (mm written as cm), a decimal point moved, a number copied to the wrong row”, then “if a slip explains it, correct the table and say so in your report — never quietly delete a point, and never keep one you know is wrong”. A footer says: an anomaly is a question, not a mistake — it may be a slip, or it may be the most interesting thing in the data

Before the checks, one quick habit this book wants you to form (§5.2): the **sensible test**. Estimate what the 60 cm dent *should* be — the points either side say somewhere around 6.5–7 mm — and compare with 3.1 mm. A higher drop making a dent *half* the size is not sensible in this setup, so the value earns its question mark before any repeat is done. Estimation is not guessing the answer; it is knowing roughly what shape the answer should have, so that a recording slip cannot walk past you.

Then the checks. Was the measurement repeated, and does the odd value appear more than once? One odd reading that repeats is data — the world really does that sometimes, and a pattern with an exception is still evidence, honestly reported. One odd reading that disappears on repeat was a slip. And if a repeat is not possible, hunt the usual slips: a misread scale, units mixed up, a decimal point moved, a number copied to the wrong row. If a slip explains the value, correct the table **and say so in the report** — the correction is part of the science, not a confession of failure.

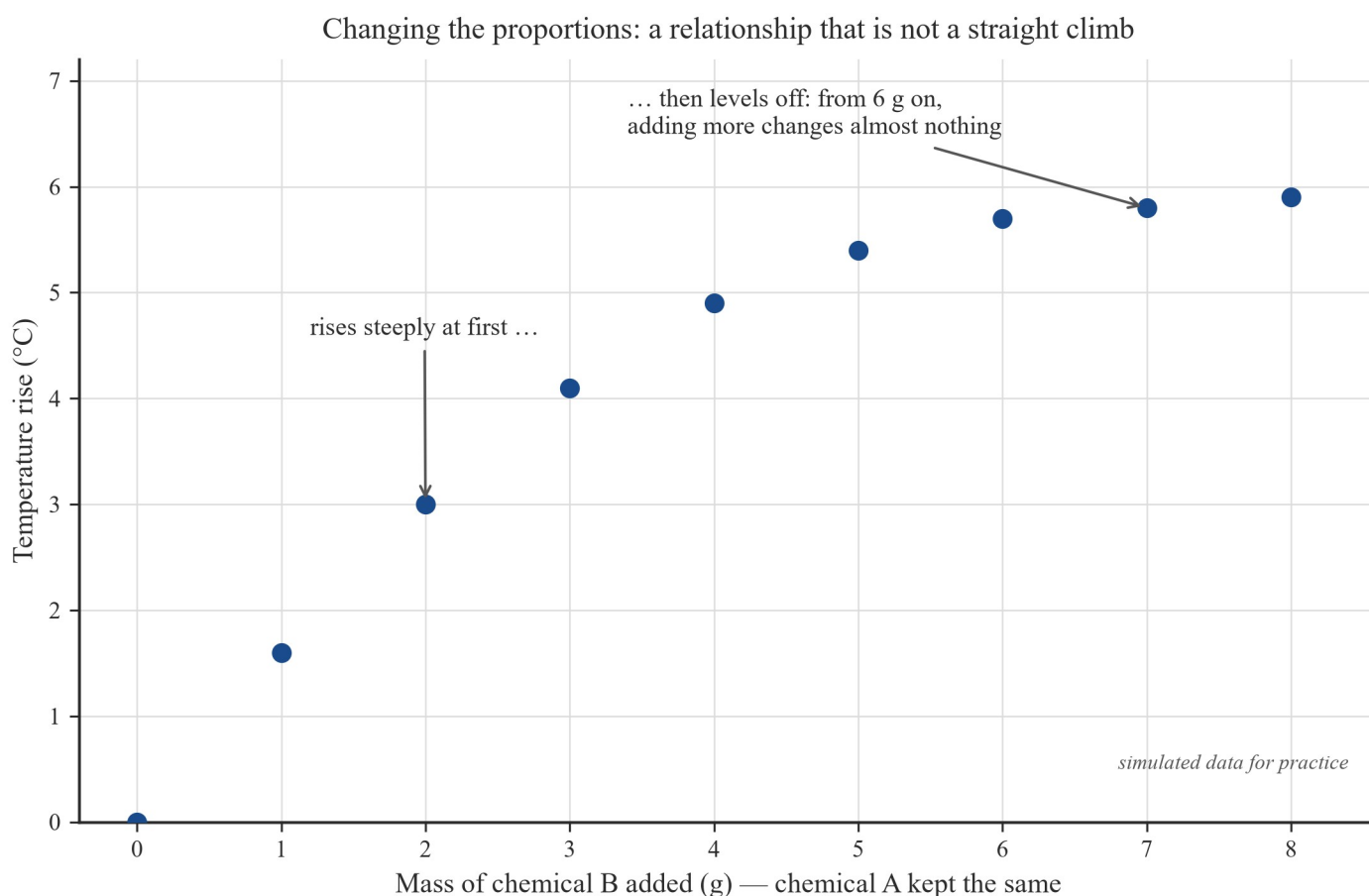
Try it 5 — slip or finding?

A group's recycling-mass record reads: week 1, 42 kg; week 2, 44 kg; week 3, 45 kg; week 4, 47 kg; week 5, 48 kg; week 6, 5.1 kg.

1. Apply the sensible test: roughly what should week 6 be?
2. Name the most likely slip on the checklist, given how 5.1 and the expected value look.
3. The group repeats the weighing and gets 51 kg. Write the one sentence their report should include about the first 5.1 kg value.

A relationship that is not a straight climb (VC2S8I05.E04)

Not every relationship is “as X increases, Y increases” at the same rate all the way along. VC2S8I05.E04 compares temperature rises from reacting different proportions of the same chemicals; here is a class table of that kind, with the mass of chemical B changed and chemical A kept the same.



Scatter plot titled “Changing the proportions: a relationship that is not a straight climb”, labelled “simulated data for practice”, plotting temperature rise (degrees Celsius) against the mass of chemical B added in grams while chemical A is kept the same; the rise climbs quickly at first — 0.0 °C at 0 g up to 4.9 °C at 4 g — then levels off, so that from 6 g on, adding more B changes almost nothing

The same data as a processed table:

Mass of
chemical
B added

(g)	0	1	2	3	4	5	6	7	8
Tempera ture rise (°C)	0.0	1.6	3.0	4.1	4.9	5.4	5.7	5.8	5.9

Move 2's shape word is **levelling off**: a steep climb early, then a flattening. Move 4's sentence therefore needs two clauses: *as more of chemical B is added, the temperature rise increases at first — then levels off, and adding more B changes almost nothing*. A student who writes only “the more B, the bigger the rise” has described the first half of the table and called it the whole. Reading a relationship means reading the *whole* shape, including the part where the relationship changes its mind. (Why it levels off is a chemistry story — one of the chemicals runs out first — and is kept for the chemistry chapters; the data is read here, not explained.) No chemical theory is needed for move 4, and that is the point: the analysis skill works on any data, whatever the story behind it.

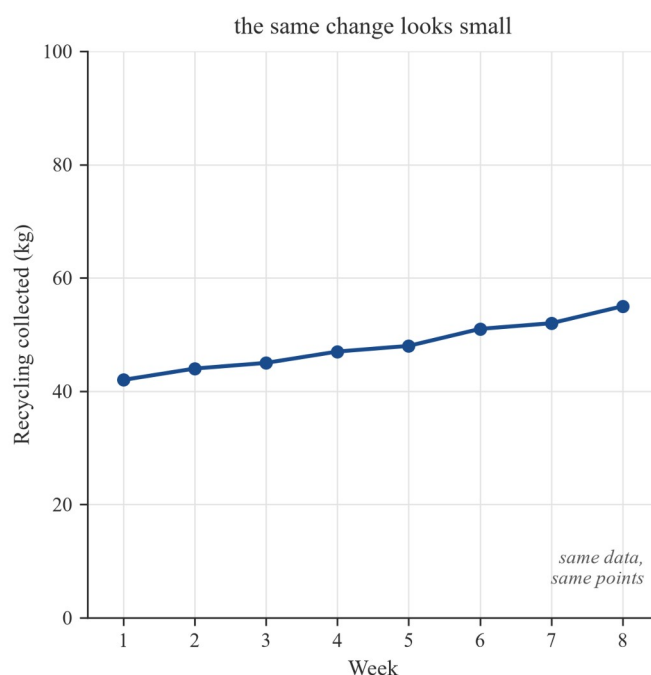
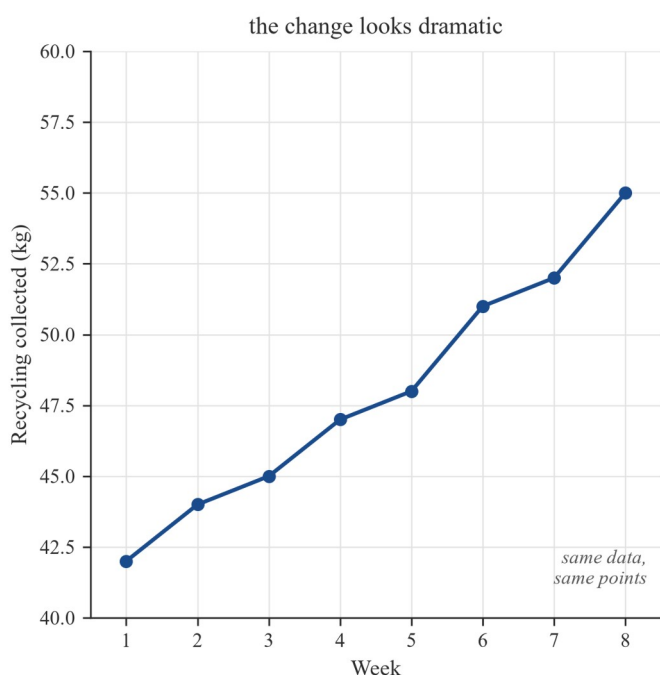
Try it 6 — read the proportions data (VC2S8I05.E04)

1. Describe the relationship between the mass of B and the temperature rise in one sentence that includes the levelling off.
2. From 0 g to 2 g, each extra gram of B adds roughly how much rise? And from 6 g to 8 g? What does that comparison tell you about the relationship?
3. Which of the four shape words names this data set?

Reading carefully — two traps for a quick eye

Trap 1: the axis tells the story. The same data can be made to look dramatic or dull by the choice of vertical scale.

The only difference is the vertical scale — read the axes before you believe the story

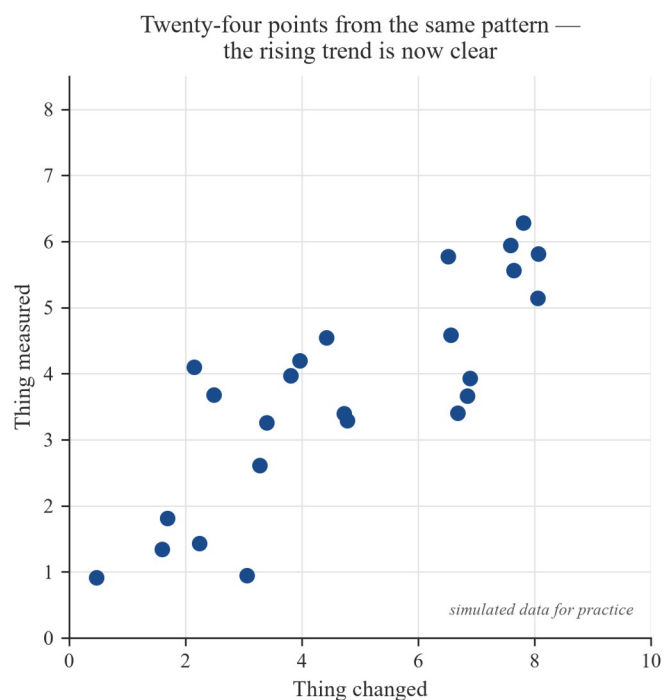
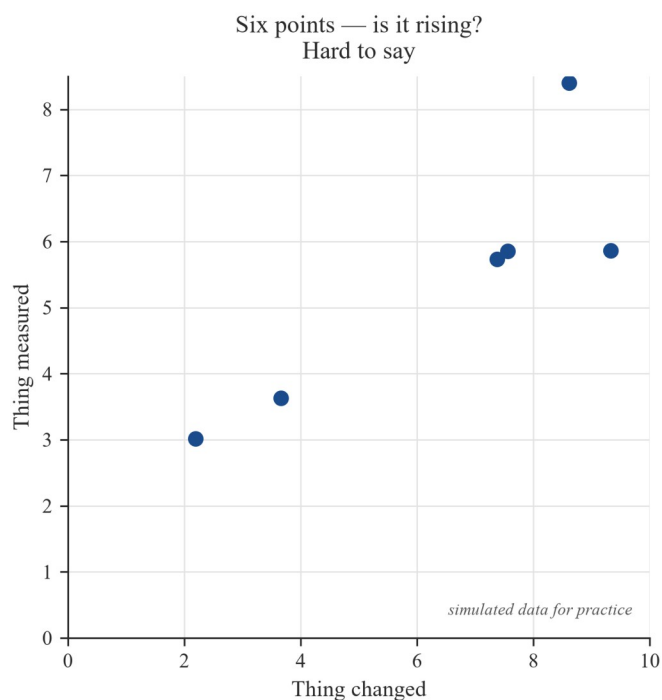


Two line graphs under the title “The only difference is the vertical scale — read the axes before you believe the story”, both labelled “same data, same points” and plotting recycling collected in kilograms against weeks 1 to 8: the left graph uses a vertical scale from 40 to 60, so the climb from 42 to 55 kg looks dramatic; the right graph uses a scale from 0 to 100, so the same climb looks small

Both panels hold exactly the same eight points. Neither is lying — the scales are honest — but the *impression* is manufactured by the axis, which is why move 1 comes before move 2. Read the axes, and “dramatic” becomes “a rise of 13 kg on a base of 42 kg — about a quarter up”, a sentence that cannot be bent by redrawing. That estimating habit is the shield.

Trap 2: small samples wobble. Six points can hide a real relationship or invent a fake one; twenty-four points from the same process make the shape plain.

Small samples vary more; more points make the pattern safer to name



Two scatter panels under the title “Small samples vary more; more points make the pattern safer to name”, both labelled “simulated data for practice” and plotting the thing measured against the thing changed: the left panel holds only six scattered points, captioned “is it rising? hard to say”; the right panel holds twenty-four points drawn from the same pattern, in which the rising trend is clear

The mathematics of *why* bigger samples settle down is VC2M8ST03’s; the reading habit is ours: when a data set is tiny, hold your trend and relationship sentences loosely, and say “more data would firm this up” instead of pretending six points are twenty-four.

Say what you see

Analysis ends in a sentence. A finding you cannot write down is a finding you do not have yet. The four moves each have a sentence shape, and the shapes are the point — make them your own.

Saying what you see — sentence starters for reports

Pattern	“The number of shearwaters is highest from November to March and lowest in June and July. The same shape repeats each year.”
Trend	“Over the twenty years, whale sightings show a rising trend — from about 60 in 2005 to about 190 in 2024.”
Relationship	“As the drop height increases, the dent depth increases. The two quantities change together.”
No relationship	“The points are scattered with no clear pattern — the data show no relationship between the two quantities.”
Anomaly	“The point at 60 cm does not fit the rising pattern. It was checked and repeated, and the second reading sat with the pattern.”

Chart titled “Saying what you see — sentence starters for reports”, with five coloured tabs each paired to a model sentence: Pattern — “The number of shearwaters is highest from November to March and lowest in June and July. The same shape repeats each year.” Trend — “Over the twenty years, whale sightings show a rising trend — from about 60 in 2005 to about 190 in 2024.” Relationship — “As the drop height increases, the dent depth increases. The two quantities change together.” No relationship — “The points are scattered with no clear pattern — the data show no relationship between the two quantities.” Anomaly — “The point at 60 cm does not fit the rising pattern. It was checked and repeated, and the second reading sat with the pattern.”

Worked examples

Example 1 — scaffolded

Use the shearwater bar chart and the four moves.

- Describe the pattern across the year in two sentences.
- A first-time reader calls the zero counts in June and July anomalies. Explain why they are not.
- Predict, with a reason, roughly how many birds the island will hold next December.

Working	Comment
(a) The count is high (around 36–39 thousand) from November to March, falls through autumn to zero in June and July, and climbs back through spring. The same shape repeats every year.	A pattern description names the shape <i>and</i> the repeat — move 2 doing both jobs.
(b) The zeros sit <i>inside</i> the repeating shape — the empty winter happens every year, so it is part of the pattern, not a point breaking it.	The anomaly test is “does it break a shape that repeats?” — June and July pass the pattern, so they are not anomalies.
(c) About 38–39 thousand, the same as this December and last. A repeating pattern licenses the prediction: that	The prediction is allowed <i>because</i> the shape repeats — say so and the mark follows.

is what a pattern is for.

Example 2 — scaffolded

Use the drop-height scatter.

- Write the relationship shown by the ten blue points as one sentence.
- Identify the anomaly.
- The group repeats the 60 cm drop and gets 6.8 mm. What was the 3.1 mm reading, and what should the report say?
- Give one reason the relationship here is reasonably read as causal, not just a togetherness.

Working

Comment

(a) As the drop height increases, the dent depth increases.

Move 4's sentence shape, verbatim.

(b) The 60 cm point, at 3.1 mm — far below the shape the other ten points make.

Naming an anomaly means giving its coordinates, not just pointing.

(c) A slip — the odd reading disappeared on repeat. The report should say the 60 cm value was first recorded as 3.1 mm, was found to be a recording slip, and was corrected to 6.8 mm.

One odd reading that disappears was a slip — and the correction is stated in the report, never made quietly.

(d) Any one of: the drop height was set by the experimenter, so it comes first; it was the only thing changed (same mass, same clay); there is a sensible story — higher fall, faster arrival, harder hit.

Causality is argued with checks (2A), not asserted.

Example 3 — unscaffolded

A student writes up the chemical-proportions data as: “*As more of chemical B is added, the temperature rise increases. The relationship is a straight climb.*” Evaluate both sentences against the data, using values from the table.

The first sentence is half right: from 0 g to about 4 g the rise does increase with each gram added — 0.0 to 1.6 to 3.0 to 4.1 to 4.9 °C. But it leaves out the second half of the table, where from 6 g to 8 g the rise creeps from 5.7 to 5.8 to 5.9 °C and adding more B changes almost nothing. The second sentence is therefore wrong: a straight climb would keep adding roughly the same rise per gram all the way along, and this data clearly levels off. A fair one-sentence read is: *the temperature rise increases quickly at first, then levels off as more B is added* — the shape word is **levelling off**, and the relationship is real but not a straight climb. Reading only the first half of a shape and calling it the whole is the classic move-2 error, and this is exactly the case VC2S8I05.E04 asks you to catch.

Example 4 — unscaffolded

A newsletter celebrates the recycling data with the headline “*Recycling doubles in eight weeks!*”, printed above a graph like the left-hand panel (vertical scale 40–60). Use the sensible test and the axis rule to evaluate the headline.

Move 1 first: the axis runs 40–60, so the eye sees only the top slice of the scale — the dramatic look is manufactured by the axis, not by the data. The sensible test does the rest with easy estimating: the series runs 42 kg to 55 kg, a rise of 13 kg. Doubling 42 would mean reaching at least 84 kg, and 55 is nowhere near 84 — the rise is about a quarter of the starting value (13 on 42), not a doubling. ∴ the headline is false: the data show a steady, modest rise, and the “dramatic” impression comes from the scale choice. The honest one-sentence read is *recycling collected rises steadily from 42 to 55 kg over the eight weeks — up by about a quarter, not doubled*. This is the estimation habit of §5.2 doing its job: a reader who knows roughly what “double” means cannot be caught by a redrawn axis.

Practice questions

Scaffolded

Q1. About the reading map. (a) Which move comes first, and what does it check? (b) Which move finds the red 60 cm point? (c) Which move ends in an “As X increases, Y ...” sentence?

Q2. About the shape words. (a) Which shape word names the shearwater year? (b) Which names the twenty-year whale record? (c) Which names the chemical-proportions data?

Q3. About primary and secondary data. (a) Your class measures cooling water every two minutes for half an hour. Which kind is that? (b) You read twenty years of whale sighting counts kept by a museum. Which kind is that? (c) What one extra question does secondary data add to the four moves?

Q4. About the tide pattern (VC2S8I05.E01). (a) At which Moon shapes is the daily range largest? (b) Roughly how long is one full lunar cycle, as shown on the graph? (c) Why is the tide record called a *pattern* rather than a *trend*?

Q5. About trend and variation. (a) State the direction of the whale-sighting trend. (b) Does the fall between two neighbouring years break the trend? Why? (c) One phrase from the rabbit timeline that shows a rise with no level-off.

Q6. About the anomaly checks. (a) If the odd value *repeats* when the measurement is redone, what is it? (b) Name two slips from the checklist. (c) What two things must you never do with a point you know is wrong?

Un scaffolded

Q7. Describe the shearwater pattern in two sentences, and explain in one more why the zero counts in June and July are part of the pattern rather than anomalies. (3 marks)

Q8. About the whale record. (a) Write the twenty-year trend as one sentence with rough starting and ending values. (b) A student says, “*The count fell from 2012 to 2013, so there is no trend.*” Answer them in two sentences. (3 marks)

Q9. About the drop-height scatter (VC2S8I05.E03). (a) Write the relationship sentence. (b) Identify the anomaly with its two values. (c) The repeat drop gives 6.8 mm. State what the 3.1 mm reading was and the one sentence the report should carry. (3 marks)

Q10. Using two of 2A’s checks, argue that the drop-height-and-dent-depth relationship is causal rather than a chance togetherness. (2 marks)

Q11. About the proportions data (VC2S8I05.E04). A report claims “*the more of chemical B added, the bigger the temperature rise, all the way along.*” Use two pairs of values from the table to show where the claim holds and where it fails, and give the correct shape word. (3 marks)

Q12. The two recycling graphs hold the same eight points yet tell different stories. Explain, in two sentences, why they look different and what a careful reader does before believing either. (2 marks)

Q13. Which sample-size panel makes the rising relationship safer to name, and why does the other panel deserve a “more data would firm this up” note? (2 marks)

Q14. A report on the recycling data claims the program “*roughly doubled*” the mass collected across the eight weeks. Apply the sensible test with an estimate, and give the honest one-sentence read of the data. (3 marks)

Answers

Q1. (a) Move 1 — read the title and the axes: what is measured, in what units, over what range. (b) Move 3 — look for anomalies. (c) Move 4. **Q2.** (a) Repeating. (b) Rising (a rising trend). (c) Levelling off. **Q3.** (a) Primary. (b) Secondary. (c) Who measured this, how, and why? **Q4.** (a) New and full moon. (b) About 29.5 days. (c) The shape repeats, so you can say what comes next — a trend travels instead of repeating. **Q5.** (a) Upward/rising across the twenty years. (b) No — a trend is the long direction; one wobble is variation, not a break. (c) “A rise that never levels off within the record.” **Q6.** (a) Data — a real finding, reported honestly. (b) Any two of: a misread scale; units mixed up; a decimal point moved; a number copied to the wrong row. (c) Never quietly delete it, and never keep it as if nothing were wrong. **Q7.** High Nov–Mar, zero Jun–Jul, back in spring; the shape repeats each year. The zeros repeat every year inside the shape, so they are part of the pattern. **Q8.** (a) Sightings rise from about 60 a season in 2005 to about 190 in 2024. (b) A trend is the long direction across all twenty years; one year’s fall is wobble/variation inside an upward trend. **Q9.** (a) As the drop height increases, the dent depth increases. (b) The 60 cm point at 3.1 mm. (c) A recording slip; the report should say the value was first recorded as 3.1 mm, found to be a slip on repeat, and corrected to 6.8 mm. **Q10.** Any two of: the height was set by the experimenter so it comes first; it was the only thing changed (same mass, same clay); sensible story — higher fall arrives faster and hits harder. **Q11.** Holds early: 0→2 g takes the rise 0.0→3.0 °C. Fails late: 6→8 g takes it only 5.7→5.9 °C. Shape word: levelling off. **Q12.** The vertical scales differ (40–60 vs 0–100), so the same climb looks dramatic or small. A careful reader reads the axes (move 1) and estimates the actual change before judging. **Q13.** The 24-point panel — more points make the shape plain. Six points wobble enough that “rising” is a guess; more data would firm it up. **Q14.** 42 to 55 kg is +13 kg, about a quarter up; doubling would need about 84 kg. Honest read: a steady modest rise, not a doubling.

Fully-worked solutions

Q1. (a) **Move 1 — read the title and the axes:** what is measured, in what units, over what range; skipping it risks describing the wrong quantities. (b) **Move 3** — looking for anomalies is what catches the red 60 cm point. (c) **Move 4** — saying the relationship in one sentence.

Q2. (a) **Repeating** — the year’s shape returns each year. (b) **Rising** — the record travels upward; the proper phrase is a *rising trend*. (c) **Levelling off** — steep climb first, then flat.

Q3. (a) **Primary** — the class did the measuring. (b) **Secondary** — somebody else collected it and you read their record. (c) **Who measured this, how, and why?** — the extra question secondary data adds.

Q4. (a) Largest at **new and full moon** (spring tides), smallest at the **quarter moons** (neap tides). (b) **About 29.5 days** — one lunar cycle. (c) Because **the shape repeats**, so you can say what comes next; a trend *travels* rather than repeating.

Q5. (a) **Upward** — from about 60 sightings a season to about 190 across the twenty years. (b) **No** — the trend is the long direction; a single fall is **year-to-year variation inside the trend**, not a break in it. (c) “**A rise that never levels off within the record.**”

Q6. (a) **Data — a real finding**, reported honestly; a pattern with an exception is still evidence. (b) Any two of: **a misread scale; units mixed up (mm written as cm); a decimal point moved; a number copied to the wrong row.** (c) **Never quietly delete the point, and never keep one you know is wrong.**

Q7. One mark per job. The pattern: **high (around 36–39 thousand) from November to March, falling through autumn to zero in June and July, climbing back through spring — and the same shape every year** (1 mark). Why the zeros are not anomalies: **they repeat every year inside the shape, so the empty winter is part of the pattern** — an anomaly must *break* a shape that repeats (1 mark). A closing sentence such as *the birds are at sea in winter* ties the pattern to the migration (1 mark).

Q8. (a) **Sightings show a rising trend, from about 60 a season in 2005 to about 190 in 2024** — direction plus rough ends (1 mark). (b) **A trend is the long direction across all twenty years; one year’s fall is wobble (variation) inside that rise**, so a single down-step does not break the trend — if it repeated for many years, *then* the trend claim would need checking (2 marks).

Q9. (a) **As the drop height increases, the dent depth increases** (1 mark). (b) **The 60 cm point, at 3.1 mm — far below the shape the other ten points make** (1 mark). (c) **The 3.1 mm was a recording slip — the odd reading disappeared on repeat**; the report should say *the 60 cm value was first recorded as 3.1 mm, was found to be a slip, and was corrected to 6.8 mm* — corrections are stated, never made quietly (1 mark).

Q10. One mark per check well used. **The drop height was set by the experimenter, so it comes before the dent** (1 mark); **it was the only thing changed — same mass, same clay every drop — and there is a sensible story: a fall from higher arrives moving faster and hits harder** (1 mark). Together those checks make the togetherness reasonably causal, not chance.

Q11. Where the claim holds: **from 0 g to 2 g each added gram brings a big rise — 0.0 to 3.0 °C** (1 mark). Where it fails: **from 6 g to 8 g the rise moves only 5.7 to 5.9 °C — adding more B changes almost nothing**, so “bigger all the way along” is false (1 mark). Correct shape word: **levelling off** (1 mark).

Q12. They look different because **the vertical scales differ — 40–60 on the left makes the climb look dramatic, 0–100 on the right makes the same climb look small; the points are identical** (1 mark). A careful reader **reads the axes first (move 1) and works out the actual change (42 to 55 kg) before judging how big the story is** (1 mark).

Q13. The **twenty-four-point panel** makes the relationship safer: with more points the rising shape is plain to see (1 mark). The six-point panel wobbles enough that “rising” is a guess, so it deserves **“more data would firm this up” — small samples vary more** (1 mark).

Q14. The estimate: **42 kg doubling would be about 84 kg, and 55 kg is nowhere near it — the rise is 13 kg on 42, about a quarter, not a double** (2 marks). The honest read: **recycling collected rises steadily from 42 to 55 kg across the eight weeks — a modest, steady rise, not a doubling** (1 mark).

Sources

- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description VC2S8I05 and its elaborations, 2026. vcaa.vic.edu.au — retrieved 2026-08-21.

All numerical series in the figures and questions (the lunar-cycle tide curves, the shearwater monthly counts, the twenty years of whale sightings, the drop-height/dent-depth scatter, the chemical-proportions scatter, the recycling weekly masses, and the two sample-size panels) are **simulated data for practice**, labelled as such in each figure; they are teaching data shaped like the real records, not measurements, and carry no source claim. The rabbit timeline is the standard historical account — wild rabbits released near Geelong in 1859, spreading fast through the 1870s, across most of southern Australia by 1900 — drawn qualitatively as an example of secondary data; it states no counts and makes no numerical claim. The Moon-phase positions on the tide graph (new, quarters, full at their standard places in the 29.5-day cycle) are the standard cycle, not data.

Elaboration contexts used: VC2S8I05.E01 (the tide-and-lunar-cycle repeating pattern), VC2S8I05.E02 (the shearwater year, the whale-sighting trend and the rabbit spread as population-change secondary data), VC2S8I05.E03 (the drop-height/indentation relationship analysed for causality, with the 60 cm anomaly) and VC2S8I05.E04 (the proportions data with its levelling-off relationship).

Teacher-facing note (not student text). 4C owns VC2S8I05 whole; the four elaborations are contexts, per D12. The D11 maths interlocks (VC2M7A04/VC2M7A05 graph reading, VC2M8ST03 sample size and variation) are relied on as already-taught maths, never taught here; gradient and lines of best fit (VC2M9A04, VC2M10ST02) are out of band and do not appear, so every graph is read qualitatively by shape. Ceilings held per D9: the Moon–tide mechanism is named as 14B’s and not explained; the chemistry behind the levelling off is deferred to the chemistry chapters; evaluating data sources is touched only as a forward reference to 5A. Forward references (2A’s causality toolkit, 4A’s spread, §5.2 estimation) point without teaching, per D8–D9. No Aboriginal and Torres Strait Islander content is drawn on here: VC2S8I05 carries no such elaborations, and D10’s sourced treatments sit in the subtopics the TOC names.

Test A

Topic 2 test — Planning, measuring and processing · Chapter 4 · Covers Chapter 3 and Chapter 4 (subtopics 3A, 3B, 3C, 4A, 4B and 4C)

This is a school-designed paper. It is not a VCAA instrument. Levels 7 and 8 carry no VCAA examination and no external assessment (D14); this paper is a school-based assessment instrument of this book's own design, graded against the achievement-standard extracts of VC2S8I02, VC2S8I03, VC2S8I04 and VC2S8I05. Achievement at Levels 7 and 8 is reported against the Victorian Curriculum achievement standard on teacher judgement; the marks here are one source of evidence towards that judgement.

About this test

Covers	Chapter 3 — Planning and conducting, and Chapter 4 — Processing, modelling and analysing; subtopics 3A, 3B, 3C, 4A, 4B and 4C
Content descriptions	VC2S8I02 (3A and 3B) · VC2S8I03 (3C) · VC2S8I04 (4A and 4B) · VC2S8I05 (4C)
Total marks	40 — Test A 10 marks, Test B 30 marks
Inquiry marks	40 of 40 — every item on this paper is inquiry-strand (paper minimum: 5)
Suggested time	45 minutes

How to run this test

- A scientific calculator is permitted for this paper. No formula sheet. No reading time.
- **Untimed completion** — the suggested time is a guide only. A student may take all the time they need.
- **Reading support** — any item may be read aloud to a student who asks. Reading is not being assessed.
- Answer every question in the spaces provided. Show your working wherever you calculate.
- For Q13(c), students draw their graph on grid paper supplied by the teacher.

Choose the best answer for each of the 10 questions. Each question is worth 1 mark.

Q1. You test whether water at 15, 30, or 45 degrees Celsius changes how long 5 grams of sugar takes to dissolve. You use 120 millilitres of water in every trial. Which detail is a control variable? (1 mark)

- A. The water temperature
- B. The time until the sugar disappears
- C. The volume of water
- D. The amount of sugar still visible after one minute

Q2. You test whether different amounts of liquid fertiliser affect the number of leaves on bean plants. You give every plant the same water, seed type, soil, and pot size, but some pots are at a sunny window and others are near a shaded wall. Which variable has not been controlled? (1 mark)

- A. The fertiliser amount
- B. The number of leaves
- C. The amount of water
- D. The hours of light received

Q3. You test whether paint colour affects how much water warms in metal cans under a lamp. All cans are the same size and material, but the black paint dries dull and the white paint dries shiny. Which feature should be made the same? (1 mark)

- A. The paint colour
- B. How shiny or dull the paint is
- C. The final water temperature
- D. The change in water temperature

Q4. You need to pour 18 mL of coloured water to the nearest millilitre in one pour. Which equipment should you use? *(1 mark)*

- A. A 25 mL measuring cylinder with 1 mL markings
- B. A 100 mL beaker with 10 mL markings
- C. A 10 mL measuring cylinder with 1 mL markings
- D. A 50 mL measuring cylinder with 5 mL markings

Q5. You use a measuring cylinder with marks every 2 mL. At eye level, the lowest point of the water surface is halfway between the 32 mL and 34 mL marks. You may estimate halfway. What volume should you record? *(1 mark)*

- A. 32 mL
- B. 33 mL
- C. 34 mL
- D. 33.5 mL

Q6. You measure three masses to the nearest 0.1 gram: 12.1 grams, 12.4 grams, and 12.6 grams. Their average is 12.366... grams. If you report the average to the same 0.1-gram precision, what should you write? *(1 mark)*

- A. 12.37 grams
- B. 12.3 grams
- C. 12.400 grams
- D. 12.4 grams

Q7. You count earthworms found in four equal soil samples. Which representation would make the four counts easiest to compare at a glance? *(1 mark)*

- A. A table listing each count
- B. A bar graph with one bar for each soil sample
- C. A labelled diagram of soil layers
- D. A three-dimensional model of an earthworm

Q8. You are using a graph from another group to repeat an experiment. Its horizontal axis is labelled only “amount” and has tick marks at 5, 10 and 15. The vertical axis is labelled time in seconds. What missing information most limits your ability to repeat the experiment? *(1 mark)*

- A. What the amount refers to and which unit was used
- B. The colour used for the graph line
- C. The order in which the line was drawn
- D. Whether the vertical axis reads upward

Q9. You measure the height of a bean plant each week. The heights are 5, 7, 9, 11, 13 and 15 centimetres. Which conclusion is justified by the data? *(1 mark)*

- A. The plant has a 2-centimetre period.
- B. The plant has a 5-week period.
- C. The plant shows an upward trend, but no repeating cycle is shown.
- D. The height of 11 centimetres is an anomaly.

Q10. You compare rainfall totals for April over six years. The totals are 42, 45, 43, 118, 44 and 46 millimetres. You are told that weather conditions were similar in most of these Aprils. Which value is the most likely anomaly? (1 mark)

- A. 42 millimetres
- B. 45 millimetres
- C. 46 millimetres
- D. 118 millimetres

Test B

Answer every question in the spaces provided. Show your working wherever you calculate. Questions 11–15 are worth 30 marks.

The investigation

A group investigates the question: *Does changing the mass hung on a rubber band change how far the rubber band stretches?* The distance the bottom of the band moves down from its unloaded position is called the **extension**.

Their method, as they wrote it:

1. Hang one rubber band from a hook fixed to the bench. Tape a ruler with millimetre marks vertically beside the band.
2. With no mass hung, read the position of the bottom of the band. The extension at 0 g is 0.0 cm.
3. Hang a 50 g mass on the band. Wait until the band stops moving, then read the position of the bottom of the band at eye level. The extension is how far that position is below the 0 g position.
4. Repeat step 3 two more times at 50 g. Unload the band between trials.
5. Repeat steps 3 and 4 for masses of 100 g, 150 g and 200 g.

Safety: masses stay on the bench except while hung on the band, and feet stay clear of the hanging mass. Nobody stretches the band past the 200 g load, and faces stay out of the line of the band in case it snaps.

Their raw results (simulated data for practice), in the order the group wrote them down:

At 150 g: 3.6 cm, 5.4 cm, 3.9 cm. At 0 g: 0.0 cm, 0.0 cm, 0.0 cm. At 200 g: 4.9 cm, 5.0 cm, 5.1 cm. At 50 g: 1.2 cm, 1.3 cm, 1.4 cm. At 100 g: 2.5 cm, 2.4 cm, 2.6 cm.

The questions are worth 30 marks in total:

Question	Assesses	Marks
11	Planning: variables, assumptions, risk and reproducibility (VC2S8I02)	8
12	Precision: reading and recording to the finest graduation (VC2S8I03)	5
13	Organising and representing data: the supplied data set to table and graph (VC2S8I04, VC2S8I03)	10
14	Patterns, trends, relationships and anomalies (VC2S8I05)	5
15	Strengths and limits of representations (VC2S8I04)	2
	Total	30

Q11. Use the investigation above. (8 marks)

- (a) Identify the independent variable. (1 mark)
- (b) Identify the dependent variable. (1 mark)
- (c) Identify two controlled variables — two things the method keeps the same on purpose. (2 marks)
- (d) State one assumption the method makes without checking. (1 mark)
- (e) Identify one risk in this investigation and say how the method manages it. (2 marks)
- (f) Give one detail the group should add to their method so another class could reproduce their investigation exactly. (1 mark)

Q12. The group reads their ruler to the nearest millimetre. (5 marks)

- (a) In one reading, the bottom of the band sits two small marks past the 4.6 cm mark on the ruler. Record this reading with its unit. (1 mark)
- (b) Why does the reader keep their eye level with the bottom of the band when reading the ruler? (1 mark)
- (c) The method reads extensions up to about 6 cm. Which instrument is more appropriate for the job — a 30 cm ruler with millimetre marks, or a metre ruler with only centimetre marks? (1 mark)
- (d) Give your reason. (1 mark)
- (e) Give one reason the group takes three trials at each mass rather than one. (1 mark)

Q13. Organise, process and graph the group's results. (10 marks)

- (a) Organise the raw results into a table: one row per mass, in ascending order of mass, a column for each trial, and a column for the mean extension. Give every column a heading with the quantity and its unit. (3 marks)
- (b) Calculate the mean extension at each mass and complete the mean column of your table. (2 marks)
- (c) On the grid paper your teacher gives you, construct a line graph of the processed data: mass hung on the horizontal axis, mean extension on the vertical axis. (5 marks)
- (d) Label both axes with the quantity and its unit, and give the graph a title. (1 mark)
- (ii) Choose an even scale for each axis that uses most of the grid. (1 mark)
- (iii) Plot the five means from your table. (3 marks)

You may join your points dot-to-dot or leave them as points. Do not draw a line of best fit — that skill belongs to Levels 9–10, not this band.

Q14. Use your table and graph. (5 marks)

- (a) Describe in one sentence, naming both variables, the relationship your graph shows. (1 mark)
- (b) One trial reading does not fit the pattern of the other readings. Identify it, and give one piece of evidence from your table or graph that shows it does not fit. (2 marks)
- (c) Suggest one thing that might have happened while that reading was being taken. (1 mark)
- (d) Use your graph to predict the extension at a mass of 75 g, and show how you read the prediction from the graph. (1 mark)

Q15. The group makes a poster of the investigation. On the poster, the results are shown as a pie chart with one slice per mass. (2 marks)

- (a) Explain why a line graph is a better representation of these results than a pie chart. (1 mark)
- (b) Give one thing the table shows that the graph does not. (1 mark)

Marking guide

This guide is written so a teacher without a science background can mark the paper. Accept the student's own words wherever the meaning matches the answer given here. Spelling and grammar are not marked. Test A (the multiple-choice paper) is marked in "Section A — answers" below; Test B (the short and structured response paper) is marked in "Section B — answers and marking". Every item traces to the achievement-standard extracts of the four CDs in §4's rows for VC2S8I02, VC2S8I03, VC2S8I04 and VC2S8I05; all items on this paper are inquiry-strand items (D7). Where a later question builds on an earlier answer (Q13(c) on Q13(b), Q14 on Q13), mark the later question on the student's own processed values, not on the model's.

Inquiry-strand marks on this paper: 40 of 40 — all four CDs assessed are inquiry-strand CDs. The paper minimum is 5.

Section A — answers

Every multiple-choice item is drawn from the MCQ bank keyed to this paper's content descriptions; the bank item id keeps the §4 join. No vocabulary repair was needed. Q1–Q3 carry one typographic normalisation: the bank's options begin with a lowercase letter and are printed here with an initial capital, matching the options of Q4–Q10; the normalisation changes no key and no code. Difficulty mix: three easy (D1), four medium (D2), three hard (D3).

Q	Answer	CD	Bank item
1	C — The volume of water	VC2S8I02	VC2S8I02.E01.S01.D 1.V02
2	D — The hours of light received	VC2S8I02	VC2S8I02.E01.S01.D 2.V03
3	B — How shiny or dull the paint is	VC2S8I02	VC2S8I02.E01.S01.D 3.V06
4	A — A 25 mL measuring cylinder with 1 mL markings	VC2S8I03	VC2S8I03.E01.S01.D 1.V05
5	B — 33 mL	VC2S8I03	VC2S8I03.E01.S01.D 2.V06
6	D — 12.4 grams	VC2S8I03	VC2S8I03.E02.S01.D 3.V04
7	B — A bar graph with one bar for each soil sample	VC2S8I04	VC2S8I04.E01.S01.D 1.V05
8	A — What the amount refers to and which unit was used	VC2S8I04	VC2S8I04.E01.S01.D 3.V03
9	C — The plant shows an upward trend, but no repeating cycle is shown.	VC2S8I05	VC2S8I05.E01.S01.D 2.V04
10	D — 118 millimetres	VC2S8I05	VC2S8I05.E01.S01.D 2.V09

Section B — answers and marking

Q11 (8 marks) — inquiry: planning a reproducible investigation (VC2S8I02). Parts (a)–(d) and (f) rehearse 3A (VC2S8I02.E01 variables and assumptions; VC2S8I02.E04 reproducible design); part (e) rehearse 3B's risk-management limb.

(a) The mass hung on the rubber band. *1 mark*

(b) The extension of the rubber band — how far the bottom of the band moves down. *1 mark*

- (c) Any two things the method actually keeps the same: the same rubber band; the same hook and ruler (the setup stays in place); the same waiting rule — readings taken only after the band stops moving; the same reading point — the bottom of the band; readings taken at eye level; the band unloaded between trials. 2×1 mark No mark for something the method merely takes for granted — “the band behaves the same on every trial” is an assumption (part d), not a controlled variable; the distinction is part of what is being assessed.
- (d) Any one unstated assumption. Accept list: the rubber band behaves the same way on every trial — it does not stretch out, warm up or go soft with use; the masses are exactly what they are marked as; the ruler stays vertical and in place between readings; the 0 g reading stays valid for the whole investigation. Must be something the method takes for granted, not something it states. *1 mark*
- (e) *1 mark* for a risk belonging to this investigation, *1 mark* for the management that matches it. Accept: a mass falling on a foot — managed by keeping masses on the bench except while hung and keeping feet clear; the band snapping — managed by never stretching past the 200 g load and keeping faces out of the line of the band. The management must match the risk named.
- (f) Any one detail that would let another class repeat the investigation exactly. Accept: state the size, type or thickness of the rubber band used (or state that a new band of the same type is used for all trials); state a fixed waiting time before each reading. *1 mark*

Q12 (5 marks) — inquiry: selecting equipment and recording data with precision (VC2S8I03; rehearses VC2S8I03.E01 and .E02). Part (e) connects to repeat readings (VC2S8I02).

- (a) 4.8 cm — accept 48 mm. *1 mark*
- (b) So the reading is not shifted by looking from an angle — accept “so the reading does not look higher or lower than it really is”. *1 mark*
- (c) The 30 cm ruler with millimetre marks. *1 mark*
- (d) Its finest graduation is 1 mm, which is the precision the readings need; a ruler with only centimetre marks cannot be read to the nearest millimetre. *1 mark*
- (e) Any one of: repeat readings let the group spot a reading that does not fit the others; a mean of several readings is closer to the true value than a single reading. *1 mark*

Q13 (10 marks) — inquiry: organising and processing the supplied data set (VC2S8I04, assessed from its CD text per D12’s thin-bank note; means via the D11 interlock VC2M7ST01, rounding via VC2M7N04, plotting via VC2M7A05).

- (a) *3 marks*. Column headings with the quantity and its unit — mass hung (g); extension, trial 1 / trial 2 / trial 3 (cm); mean extension (cm) (*1 mark*); all fifteen readings placed correctly, one row per mass, masses in ascending order (*1 mark*); a mean column included (*1 mark*).
- (b) *2 marks*. The means are 0.0 cm, 1.3 cm, 2.5 cm, 4.3 cm and 5.0 cm: all five correct (*2 marks*), three or four correct (*1 mark*). Sample working: at 150 g, $(3.6 + 5.4 + 3.9) \div 3 = 12.9 \div 3 = 4.3$ cm.
- (c) *5 marks*. Both axes labelled with the quantity and its unit — mass hung (g) horizontal, mean extension (cm) vertical — and a title, for example *Mean extension of a rubber band against mass hung (simulated data for practice)* (*1 mark*); even scales that use most of the grid — for example steps of 25 g or 50 g on the horizontal axis (0–200 g) and 0.5 cm or 1 cm on the vertical axis (0–6 cm) (*1 mark*); the five means from the student’s own table plotted accurately — two or three correct (*1 mark*), four correct (*2 marks*), five correct (*3 marks*). Allow half a small square either way. Points may be joined dot-to-dot or left; a line of best fit is not required (D11) and is not penalised if drawn.

Q14 (5 marks) — inquiry: analysing processed data for the relationship and the anomaly (VC2S8I05; rehearses VC2S8I05.E01 and .E03).

- (a) As the mass hung on the band increases, the extension of the band increases. Both variables must be named; a stronger answer adds the shape — in roughly equal steps of extension for equal steps of mass, apart from the anomalous point. “It goes up” without both variables named earns no mark. *1 mark*

- (b) The 5.4 cm reading in the 150 g trials. *1 mark* One piece of evidence from the table or graph: the other two trials at 150 g are 3.6 cm and 3.9 cm; or the pattern elsewhere rises about 1.2–1.3 cm per 50 g step, so about 3.7 cm is expected at 150 g; or the 150 g mean (4.3 cm) sits above the line the other points make on the graph. *1 mark*
- (c) Any one of: the ruler was misread — the wrong mark, or read from an angle; the band caught on the ruler or the hook and then released suddenly; the reading was taken while the band was still moving; the number was written down wrong in the notebook. *1 mark*
- (d) About 1.9 cm — accept about 1.8–2.0 cm. The prediction must sit between the 50 g and 100 g means (1.3 cm and 2.5 cm), and the student must show the read: find 75 g on the horizontal axis, go up to the line, go across to the vertical axis. *1 mark*

Q15 (2 marks) — inquiry: strengths and limits of representations (VC2S8I04; rehearses 4B's VC2S8I04.E01).

- (a) The results show how one quantity changes as another changes; a line graph shows that change, while a pie chart shows parts of one whole, which these results are not. *1 mark*
- (b) Any one of: the exact values; the individual trial readings — including the 5.4 cm anomaly — which a graph of means does not show. *1 mark*

Section B subtotal: 30 marks.

Data provenance and sources. Every multiple-choice item is drawn from the MCQ bank keyed to VC2S8I02–VC2S8I05 and printed verbatim; the bank item ids above keep the §4 join. The rubber-band investigation is an original teaching scenario; the readings in the results block are **simulated data for practice**, labelled as such in the paper — they are teaching data, not measurements, carry no source claim, and no real group, school or measurement is represented. Elaboration contexts drawn on: VC2S8I02.E01 (assumptions about variables taken to be constant), VC2S8I02.E04 (variables and assumptions in a reproducible investigation), VC2S8I03.E01 (equipment selected and used with the required precision), VC2S8I03.E02 (recording to the precision of the instrument), VC2S8I04.E01 (strengths and limitations of representations), VC2S8I05.E01 (mathematical relationships in data) and VC2S8I05.E03 (a correlational relationship — the greater the mass hung, the greater the extension). VC2S8I04's table-and-graph core is assessed from its CD text per D12 (4A is a thin-bank subtopic), with the D11 maths interlock carrying the processing: the mean (VC2M7ST01), rounding to the precision the data earn (VC2M7N04), plotting tables of values (VC2M7A05) and reading a graph (VC2M7A04).

Teacher-facing note (not student text). Marking is strictly point-based per §7: every mark above is tied to a stated point, and no holistic judgement is applied at any level. Graphing demand is capped by D11: gradient (VC2M9A04) and line of best fit (VC2M10ST02) are Levels 9–10 skills — neither is required here, and neither is penalised if a student produces one. This test carries no Aboriginal and Torres Strait Islander content; VC2S8I02's protocol limb (3B's .E05 and .E06) is assessed through SIT-2's risk assessment and ethics statement, as §7 specifies — Q11(e) assesses 3B's risk-management limb. Q13(c) requires grid paper, supplied by the teacher.

Traceability

Item	Marks	CD	Achievement-standard evidence	Inquiry
Q1–Q3	3	VC2S8I02	variables identified and managed in planned investigations	3
Q4–Q6	3	VC2S8I03	equipment selected and data recorded with precision	3
Q7–Q8	2	VC2S8I04	representations selected, and what limits them	2
Q9–Q10	2	VC2S8I05	trends, patterns and	2

Item	Marks	CD	Achievement- standard evidence	Inquiry
			anomalies identified in data	
Q11	8	VC2S8I02	a reproducible investigation planned: variables, assumptions, risk managed, procedure documented	8
Q12	5	VC2S8I03	equipment selected; scale read and recorded to its finest graduation	5
Q13	10	VC2S8I04 (+ VC2S8I03, VC2M7ST01, VC2M7A05)	the supplied data set organised into a table, processed and graphed	10
Q14	5	VC2S8I05	the relationship described; the anomaly identified, explained and worked around	5
Q15	2	VC2S8I04	strengths and limits of representations	2
Total	40			40

Achievement-standard extracts served (D13), verbatim from the authority file: VC2S8I02 — “*They plan a range of reproducible scientific investigations, document procedures...*”; VC2S8I03 — “*They select and use equipment to generate and record data with precision.*”; VC2S8I04 — “*They select and construct appropriate representations to organise and process data and information.*”; VC2S8I05 — “*They analyse and connect data and information to identify and explain patterns, trends, relationships and anomalies.*”