

2027-04-13 · 80 minutes

Graph draft

Your goal: Run a two-fold dilution series to its endpoint, then draft the calibration line that turns an endpoint into a concentration.

One product: Endpoint table with the claim you predicted, your assigned known concentration, your endpoint well number, the blank result, and the pooled class results; a drafted calibration graph with titled and scaled axes; the coded unknown marked on the line with its estimated concentration; and one sentence stating how wide the estimate is and one named limitation of pooling data across teams that pipetted differently.

Question: You have a column of numbers from your environmental data set. Which graph, which axes, and which outlier calls make those numbers say something true instead of something misleading?

Start the work

Name the quantity, source and limit beside each number; a clear map can guide the next question without pretending to prove safety.

1. Use paper simulation only until the teacher confirms the actual protocol, stock, iodine SDS and permission. Copy E1's ideal doubling claim and predict the 8-milligram-per-liter endpoint before viewing D1.
2. Label a paper K1-K6 row, U1-U6 row and BL. Choose original known C unless the teacher supplies an actual assigned record; keep actual identity separate.
3. Record the nominal starting value and the five-halving concentration row from E1/D1. Note the missing post-iodine volume information; load no water or reagent.
4. Trace the five transfers on paper, record each dilution factor and explain fresh-tip purpose. Do not perform transfers, disposal or cleanup from this page.
5. Use D1's complete appearance records at their assigned read point. Call known, U and BL results; record the anomalous repeat without starting a reaction or timer.
6. Use all six D1 pooled points or the actual posted chart. Draw the correctly labeled reference graph, mark U with its conditional interval and state interteam limitations; keep authentic run/submission status explicit.

Save the same full record locally if the route is missing. Actual posted class data, run, stocks, SDS, coded unknown and official progress remain pending.

Words you will use

serial dilution

A sequence of dilutions in which each sample is made from the preceding one.

twofold dilution

An ideal dilution that halves concentration at each step.

concentration

Amount of a substance per stated volume of the mixture.

nominal concentration

An assigned or calculated concentration, not necessarily a measured result.

milligram per liter

One thousandth of a gram of substance per liter of mixture.

microliter

One millionth of a liter.

stock

The starting solution with a stated concentration.

diluent

Material added to lower a sample concentration.

Lugol's iodine

An iodine and iodide reagent formulation whose actual product and SDS must be confirmed.

SDS

Safety Data Sheet with product-specific hazards and handling instructions.

PPE

Personal protective equipment selected for the actual hazard and procedure.

indicator

A substance giving an observable response under a stated method.

blank

A comparison sample with no added target under the stated conditions.

positive

A response meeting the declared visual rule.

negative

A response not meeting that rule; it does not prove universal absence.

endpoint

The last well meeting the rule in a valid ordered series.

visual threshold

The declared response boundary for this paper model, not a validated instrument limit.

detection limit

A method-specific ability to distinguish a target from background, requiring an appropriate validation procedure.

monotonic

Moving in one direction; here positives are followed only by negatives.

coded unknown

A sample whose starting concentration is not revealed.

calibration

A relationship used to translate one measurement scale into another within its supported conditions.

reference anchor

A stated known point used to construct the model guide.

independent variable

The known starting concentration deliberately varied in this model.

dependent variable

The endpoint well number recorded as the response.

scatter plot

A graph of paired numerical values.

linear scale

An axis where equal distances mean equal numerical differences.

logarithmic scale

An axis where equal distances mean equal ratios.

log2

The power of two that gives a positive ratio.

doubling index

The base-two logarithm of the starting concentration divided by the model threshold.

dimensionless

Having no measurement unit because matching units cancel.

stepwise

Changing in discrete jumps instead of smoothly at every input value.

interval

A set of values between stated bounds.

lower bound

The smallest allowed value when that boundary is included.

upper bound

The top boundary, which may be included or excluded.

censored endpoint

A result beyond the tested row that provides only a one-sided bound.

uncertainty

The limits on what can be concluded from the method and records.

confidence interval

A statistical interval constructed by a specified procedure with a stated coverage meaning.

replicate

A repeated run under stated conditions, retaining its identity.

outlier

A point unusually far from the pattern being examined.

precision

Agreement across repeated measurements under stated conditions.

repeatability

Agreement of repeated measurements under the same specified conditions.

range

The observed minimum through maximum, or their difference when explicitly stated.

error bar

A plotted interval whose meaning and calculation must be labeled.

carryover

Unintended transfer of material from one sample into another.

interteam variation

Differences among records made by different groups or methods.

time series

Values recorded across an ordered sequence of times.

categorical variable

A variable identifying separate groups or labels.

continuous variable

A variable that can take values across a numerical interval.

correlation

An association between variables; it does not alone establish a cause.

causation

A change in one factor producing a change in another under supported evidence.

PM2.5

Fine airborne particles generally 2.5 micrometers or smaller.

microgram per cubic meter

One millionth of a gram of material per cubic meter of air.

extrapolation

Extending a model beyond the known values that support it.

graph

A visual display of values and their relationships.

axis

A reference line whose labels and scale locate plotted values.

scale

The rule linking position to a value on a graph.

trend

The overall pattern across the displayed values.

error

A departure from a correct or reference value; a surprising point alone does not identify its cause.

line graph

A display joining values in a meaningful ordered sequence.

bar chart

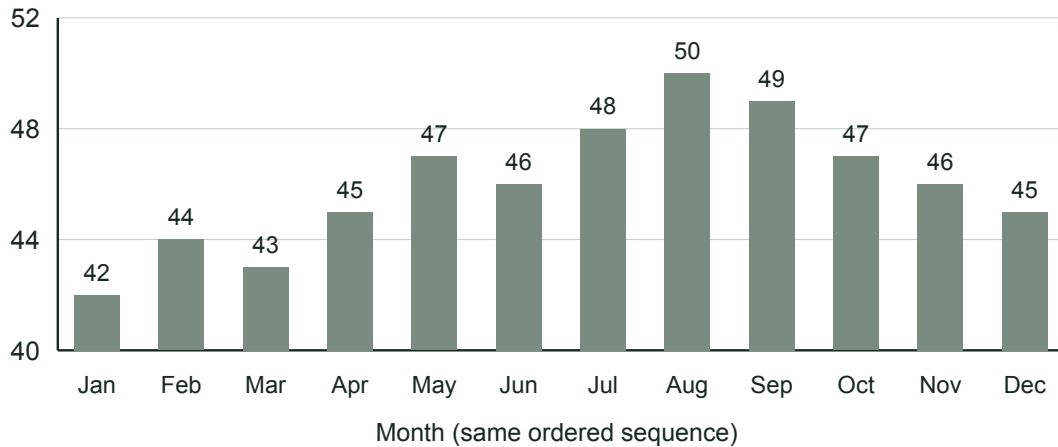
A display encoding category values as lengths from a common zero baseline.

V2: Original monthly graph comparison

V2: same original monthly values, two displays

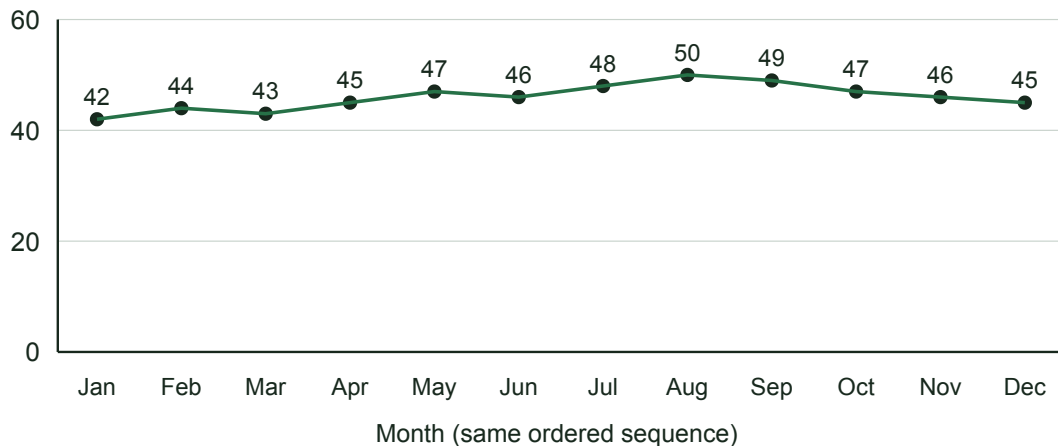
PM2.5 monthly mean (micrograms per cubic meter); invented inputs.

A: deliberate misleading bars; baseline 40



For honest columns, rebuild from zero. Time columns can be valid.

B: line emphasizes the time sequence



Choose the graph for the message; retain all values. Complete record: Q1.

Original instructional graph, not actual class or community data. Complete text equivalent in Q1.

Text description: Same twelve original PM2.5 monthly values on bars beginning at 40 and a zero-based line chart: 42, 44, 43, 45, 47, 46, 48, 50, 49, 47, 46, 45 micrograms per cubic meter. Bars are a deliberate misleading example; the line preserves all values and chronological labels.

H1: original paper run; actual bench inputs pending

This is original paper simulation. Do not load liquids, open iodine, use tips or operate a timer from this lesson. The objective still includes the actual run; this practice does not complete it.

The real run needs the teacher's starch stocks, assigned base concentration, coded sample, exact iodine formulation and Safety Data Sheet. Actual permission, equipment, plate and posted class records are also missing.

Teacher instructions must confirm PPE, eyewash access, spill response, compatible waste collection and cleanup. Do not improvise a reagent-specific response or disposal route from these notes.

The recorded row has six wells but only five transfers: 1 to 2, 2 to 3, 3 to 4, 4 to 5 and 5 to 6. Six halvings would require another well.

The recorded amounts would leave 100 microliters in each sample well before iodine after the stated final discard. One unspecified drop changes final volume; post-iodine concentration is not established.

All concentrations below are nominal starch concentrations before indicator addition. The model assumes an identical effective visual rule for every row. It is not a validated iodine method or instrument detection limit.

E1: half concentration and a declared visual rule

For ideal dilution with no material loss, concentration times volume is conserved during dilution. Equal sample and diluent volumes halve the concentration. OpenStax explains this conservation relationship.

Original rule: a nominal well concentration at or above 1 milligram per liter is called positive, meaning darker than the blank. A value below 1 is called negative, matching the blank.

The threshold T equals 1 milligram per liter only in this invented model. It is not a measured classroom threshold, an actual stock specification or a health limit.

For starting concentration C , wells 1 through 6 have C , $C/2$, $C/4$, $C/8$, $C/16$ and $C/32$. The endpoint is the last positive well when calls are monotonic.

Monotonic here means all positives precede all negatives. A positive after a negative breaks this model and must be flagged, not forced into a clean endpoint.

Before reading D1, copy the predicted claim: doubling a start should move an uncensored endpoint one well farther under this ideal rule. Predict the endpoint for an assigned original 8-milligram-per-liter row.

D1: complete original appearance and class-chart records

These are invented records, not actual teams, photographs or measurements. P means darker than the yellow-brown blank; N means matching that blank. All records share an assigned 60-second read point; no reaction took place.

BL contains zero added starch in the model and is yellow-brown. It defines the comparison appearance; it does not prove that every transfer or reagent worked.

Known A starts at 2 milligrams per liter. Wells 1-6: 2, 1, 0.5, 0.25, 0.125, 0.0625. Calls P P N N N N; endpoint 2.

Known B starts at 4 milligrams per liter. Wells: 4, 2, 1, 0.5, 0.25, 0.125. Calls P P P N N N; endpoint 3.

Known C starts at 8 milligrams per liter. Wells: 8, 4, 2, 1, 0.5, 0.25. Calls P P P P N N; endpoint 4.

Known D starts at 16 milligrams per liter. Wells: 16, 8, 4, 2, 1, 0.5. Calls P P P P P N; endpoint 5.

Repeat C2 has the same nominal 8-milligram-per-liter row as C. Its supplied calls are P P P N N N; endpoint 3. This deliberately anomalous record disagrees with the ideal rule; no cause is established.

Repeat C3 has the same nominal 8-milligram-per-liter row as C. Calls P P P P N N; endpoint 4. Retain all three 8-level records separately.

Coded unknown U has no revealed starting concentration. U1-U6 calls are P P P P N N; endpoint 4. Its concentrations remain U, U/2, U/4, U/8, U/16 and U/32 until constrained by the model.

The complete pooled chart is A:(2,2), B:(4,3), C:(8,4), D:(16,5), C2:(8,3), C3:(8,4). Each pair is start in milligrams per liter, then endpoint well number. Do not average or delete the flagged row.

E2: choose axes that match the doubling structure

The known starting concentration is the independent variable. Endpoint well number is the dependent variable. Use a scatter plot for their relationship, with concentration on the horizontal axis and endpoint on the vertical axis.

Equally spaced starting values 2, 4, 8 and 16 are not equal numerical gaps. Use a base-two logarithmic horizontal scale, or a linearized doubling-index axis.

For our linearized axis, x equals $\log_2(C/T)$, where T is 1 milligram per liter. The ratio has no units. Calculate x for each of the four starts.

$\log_2$ names the power of two giving that ratio. For example, $128/1$ equals 2 to the seventh power, so $\log_2(128/1)$ is 7. Write both the index and its concentration equivalent at each tick.

Plot all six records from D1. Where two records share one position, mark it as two records. Plot and flag C2.

The four ideal reference anchors A-D lie on one straight line. Write its rule in terms of e and x , and draw that reference segment only from the lowest to the highest anchor x . It is not a fit claiming every pooled record agrees.

Actual endpoint is a stepwise category: a band of concentrations can have the same endpoint. The straight anchor line is a reading guide, not proof of continuous exact concentration or a validated regression.

Your graph is today's product, so no finished graph is shown; E2 and D1 supply every axis rule and plotted record. Do not draw a straight reference line on evenly spaced numerical concentration values and call it the same model.

E3: recover an interval, including censored cases

For an interior endpoint e , the last positive gives $C / 2^{(e-1)} \geq T$. The next negative gives $C / 2^e < T$. Here $^$ means raised to a power.

Together, $T * 2^{(e-1)} \leq C < T * 2^e$. The star means multiplication. The lower bound is included; the upper bound is excluded.

For U , substitute its endpoint e and $T=1$ into these bounds. Mark the lower-bound anchor on the line and label the full interval; do not report an exact U value.

The upper bound is twice the lower bound. This is a multiplicative window, not a plus-or-minus range or a symmetric error bar around the lower bound.

The interval depends on an ideal threshold and correct calls. C2 shows disagreement, so a real pooled experiment could be less certain. Do not claim this is a statistical confidence interval.

Endpoint 0 means no well is positive. Use well 1's call and threshold T to write the one-sided bound on the start; it need not be zero.

Endpoint 6 means the last available well is positive. Use well 6's call and threshold T to write the lower bound; no next negative sets an upper bound. Do not invent endpoint 7.

Your lowest and highest known starts set the calibrated range. Do not extrapolate the reference line for endpoints 0 or 6. Those are model boundary checks, not calibrated unknown estimates.

R1: keep variation and limitations visible

NIST describes calibration as relating measurement scales and requiring uncertainty assessment. The ideal original line here illustrates that idea; it is not a laboratory calibration certificate.

C2 is a candidate outlier relative to the ideal anchors. Retain and flag it. Mixing, transfer volume, labeling or visual scoring are possible explanations, not established causes.

Reusing a tip can carry material forward; it does not guarantee a shift of exactly one well. Unequal indicator drops or read times may change comparability even with fresh tips.

At the 8 level, find the observed minimum and maximum of the three endpoints. You may show this range if labeled as three original records, not a confidence interval.

Other known levels have one record each. They cannot establish repeatability or precision by themselves. Do not invent error bars for unreplicated levels.

Write a trend sentence that says how endpoint changes as the known start doubles, followed by because the data shows and specific D1 pairs. Then state that the flagged repeat limits agreement.

The simulated association and model do not prove a real causal effect or a human health result. Actual interteam evidence needs matched methods, records and teacher review.

Q1: graph choices and a complete time-series check

Warmup 1 asks about water samples taken each week for ten weeks. Week is an ordered time variable; use a line or connected points to emphasize change. Warmup 2 asks for a title, axis labels, units or a readable scale.

No real Cleveland lead chart is supplied. Use this original arithmetic example instead: bars for 9 and 11 starting at 8 have visible lengths 1 and 3. Their values did not triple.

The exact self-check asks: Your data is monthly air-quality readings for one year. A classmate plots them as a bar chart with the y-axis starting at 40. Name the two problems and fix them.

Original twelve-month PM2.5 inputs, in micrograms per cubic meter: Jan 42, Feb 44, Mar 43, Apr 45, May 47, Jun 46, Jul 48, Aug 50, Sep 49, Oct 47, Nov 46, Dec 45. These are invented monthly averages, not Cleveland data.

V2 supplies the truncated bars and a clear line version with the same twelve values. The bars encode lengths from 40 and exaggerate relative sizes. Rebuild bars from zero, or use a clearly labeled line chart.

Graph type is the other decision to explain, not an automatic error. Monthly columns can validly compare levels; a line emphasizes the sequence. Defend the choice using the intended message.

Line and scatter axes need not always start at zero, but their scale must be clear. Broken bar axes do not repair misleading bar lengths. ONS recommends zero baselines for bars.

For extension, plot the same monthly values as zero-based columns and as a line; compare what a skeptical reader learns. Identify the overall rise to August and later fall without inventing a cause.

A recovery graph can start with five or six points. D1 supplies six records, so that small graph can still include the full original calibration dataset and unknown interval.

P1: authentic run, async and official work

If actual class endpoint records are posted, use them for the assigned asynchronous graph and uncertainty sentence. They require the actual stock, blank, method and coded unknown inputs. The D1 route is labeled recovery, not that class record.

Keep your predicted claim, assigned known, known endpoint, BL result, all pooled records, titled graph, unknown interval and one interteam limitation in one record. A graph alone is incomplete.

Today, open Activity 4.1.3 Testing the Waters and draft the graph in Data Tables as the current Problem 4 graphing activity. Confirm the exact assigned portion and portfolio route with your teacher.

The 4.1.3 procedure uses eleven tests on two waters, its Student Resource Sheet, actual results, health-effects notes, research and peer/remediation comparison. This starch endpoint practice does not replace that procedure.

The actual iodine formulation, stock concentrations, water-test match and blank are teacher inputs. No earlier practice series is a validated detection limit for this run.

April 15 is the next class day. No actual U concentration or reveal is supplied, and any later practice value stays separate from a real sample result.

April 12 L1 was a separate six-halving illustration. This six-well row has five halvings. Your teacher will confirm when any bench work happens; do not add a well or assume permission.

Submit the endpoint table and graph only through the teacher-confirmed enrolled BI section and current Problem 4 portfolio. Open the linked BI assignment and check its posted requirements and deadline. Save the same full original record if unavailable and record pending status.

M1: a different worked time-series and outlier decision

Original display model: a room logger reports 18, 19, 18, 25, 20 and 19 degrees Celsius at hours 1 through 6. No real room or sensor was measured.

I choose connected points because the question is how the readings change over ordered time. The horizontal axis is hour; the vertical axis is temperature in degrees Celsius.

I retain hour 4 at 25 as a flagged high point. A moved sensor or a real temperature change could explain it, but neither is established. I would check the original record and device placement.

My claim is that most readings cluster from 18 to 20 because the data shows five of six there. This pattern does not establish what caused the high value.

A column chart from zero could compare magnitudes, but the line shows sequence more directly. I keep the labels and flag rather than deleting a point to make the graph smooth.

Try the decision

U ends at well 4 under the declared threshold. C2 differs from the ideal anchors. What is the defensible report?

- Report the full conditional interval set by the last positive and next negative wells, retain C2 and state that real pooling may add uncertainty.
- Declare one exact value where the anchor line crosses U's endpoint.
- Delete C2 and report that the actual class method has proven precision.

Explain your choice using the reading. Discuss it or say it to yourself. This practice does not add another submission.

Your 80-minute flow

0–10 minutes	Read H1 safety and scope holds, answer warmups and commit the prediction.
10–25 minutes	Label the paper rows and record the four nominal concentration series.
25–45 minutes	Trace the five halvings on paper; complete all known, repeat, U and BL records.
45–55 minutes	Apply the supplied color rule, compare endpoints and flag disagreement.
55–70 minutes	Plot all pooled points, label the reference and interval, and check Q1 graph choices.
70–80 minutes	Write the unknown bound and interteam limitation; check full product and actual submission status.

Your response record

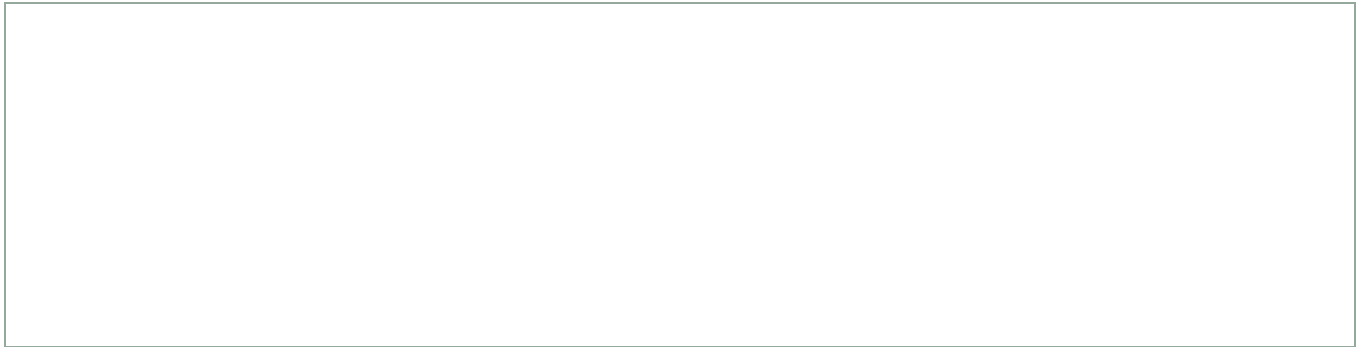
Use these labels on paper or in your document. The space below also works when this page is printed.

Predict and check readiness

Read H1 and answer both Q1 warmups. Copy the ideal doubling claim and predict known C before reading D1.

The actual laboratory branch remains pending. Six wells provide five halvings.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

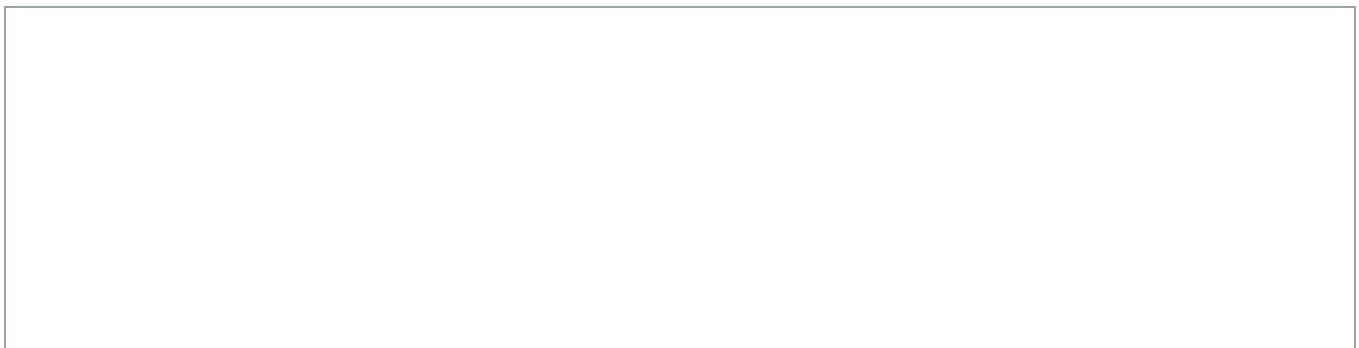


Build the complete endpoint record

Label K1-K6, U1-U6 and BL. Copy or calculate the four known concentration rows, all six pooled records and U calls. Identify variables and control meaning.

D1 supplies every original value and call. Unknown concentrations stay symbolic; no real reveal is invented.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

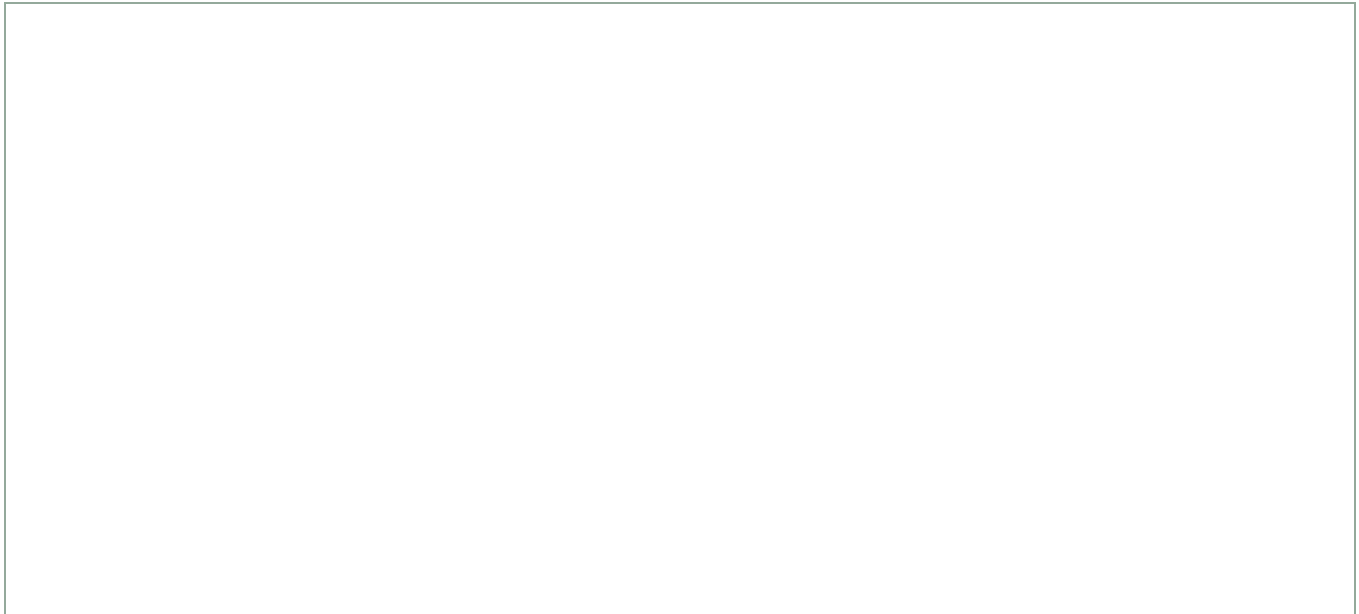


Draft the calibration graph

Use E2 and D1 to plot every pooled record with titled/scaled axes, source status and C2 flag. Explain the doubling-index ticks and ideal reference line.

Keep both overlapping records visible by their count. Do not treat a straight line as an exact continuous endpoint law.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

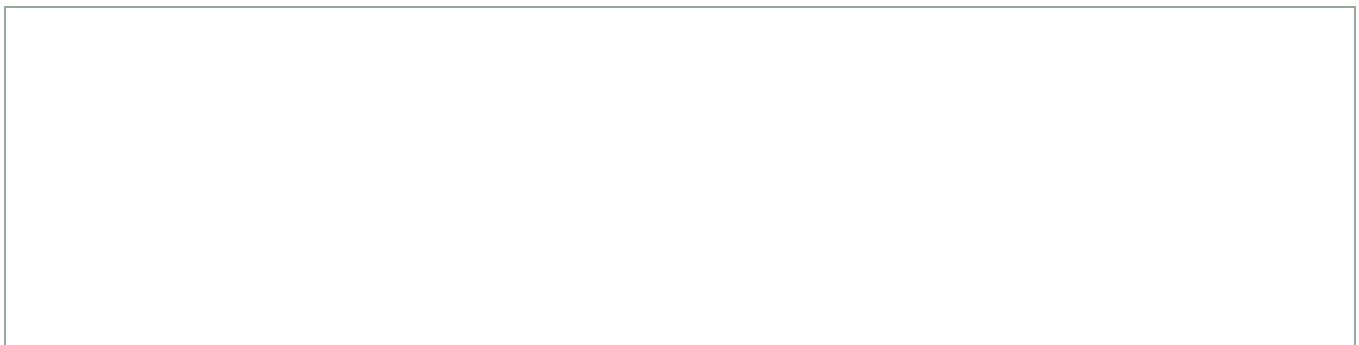


Mark the unknown and limits

Mark U on the guide and write its full included/excluded interval, factor-of-two width and interteam limitation. Explain endpoints 0 and 6 as E3 boundary checks.

State the ideal-rule condition and observed disagreement. These limits are not a statistical confidence interval.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



Defend graph choices and outliers

Write the trend and because-the-data-shows claim with a causal limit. Answer Q1 and flag rather than delete C2.

Use all twelve monthly values for the Q1 graph comparison. If ready, produce zero-based columns and line versions and defend their different messages.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.



Preserve original and actual status

Check the entire product and P1. Use actual posted class records for the async task when available; otherwise label the full D1 recovery.

Keep table, prediction, blank, graph, U interval, source and interteam limitation together. Actual stocks, SDS, run, official work and route remain pending.

Use this space or the same labeled section in your existing document. Add paper when your table, graph or drawing needs more room.

A large, empty rectangular box with a thin black border, intended for a drawing or additional notes. It occupies the lower half of the page.

Check your product

- You can name your endpoint well and say what makes it the endpoint rather than the well beside it.
- You can name your independent variable, your dependent variable, and what the blank rules out.
- You can read a concentration off the class line and state how wide the estimate is and why it cannot be narrower.

Keep the limit: Original endpoint simulation illustrates dilution, graph choice and conditional bounds. It cannot establish any actual starch concentration, precision, health claim, authentic run or official completion.

Turn in your work

Submit the full endpoint table and calibration graph through the teacher-confirmed April 13 Data Tables assignment in your enrolled BI section and current Problem 4 portfolio. Keep original simulation and actual run status distinct.

Save the same full record locally if the route is missing. Actual posted class data, run, stocks, SDS, coded unknown and official progress remain pending.

[Open this assignment in Schoology.](#)

Carry forward

Show every record and the scale rule; an endpoint supports a conditional interval, not an exact concentration.

Carry the graph, interval and flagged records into the next analysis; an actual unknown reveal remains a teacher input. How would the actual reveal change your interval comparison?

Sources and resources

[Open today's page](#)

OPENSTAX-DILUTION · Chemistry 2e: 3.3 Molarity, dilution subsection

OpenStax, Rice University

<https://openstax.org/books/chemistry-2e/pages/3-3-molarity>

NIST-CAL · Calibration

NIST/SEMATECH e-Handbook 4.1.3.3

<https://www.itl.nist.gov/div898/handbook/pmd/section1/pmd133.htm>

ONS-AXES · Axes and gridlines

Office for National Statistics

<https://service-manual.ons.gov.uk/data-visualisation/guidance/axes-and-gridlines>

ONS-COLUMN · Data over time: Column chart

Office for National Statistics

<https://service-manual.ons.gov.uk/data-visualisation/chart-types/column-chart>

EPA-PM · Particulate Matter (PM) Basics

U.S. Environmental Protection Agency

<https://www.epa.gov/pm-pollution/particulate-matter-pm-basics>