

Start here: choose a route

Target: use matched fresh trials to compare thermal protectors, change a design, and revise a claim. Grade 6 authoring target; relevant standards are in the Grades 6–8 band.

Practical route

Work under teacher supervision. Read P1-S-BRIEF through P1-S-CHECK. Record your phase's instrument checks at P1-S-DEVICE. Run three first comparisons using P1-S-F1–F3. Compare results at P1-S-A1. Read P1-S-REDESIGN and run three retests using P1-S-R1–R3; finish P1-S-A2 and P1-S-REFLECT.

Supplied-data route

No equipment is needed. Read the brief and procedure, then use P1-S-CASE1 and P1-S-CASE2, which are fictional constructed records. Complete P1-S-A1, P1-S-REDESIGN, P1-S-A2, P1-S-REFLECT and P1-S-LATER. These records are not measurements from this class.

Ways to respond

Write, dictate, explain orally to a recorder, or use a labeled sketch/table. Give the same quantities, comparison conditions and evidence in any format. Graph drawing is optional.

Water is not for drinking. Keep cups in spill trays. Do not heat, cut, puncture or modify equipment. Tell the teacher about spills, leaks, damaged equipment or an unstable cup.

P1-B: the design brief

Design a removable dry sleeve that may slow the warming of 150 mL of cool water in a covered plastic cup for 10 minutes in a classroom. This is a classroom comparison; it makes no promise about refrigeration, food, medicines or a particular final temperature.

Initial prototype P1 uses one supplied 26 cm × 6 cm felt sheet, at most 3 mm thick. Baseline P0 has no sleeve. A redesign P2 may use at most two supplied sheets total and at most 30 cm of tape. Its footprint must fit within a 12 cm diameter circle; its height must be at most 9 cm. Do not cover the base, top cover, probe slot or display.

Performance aim: look for less warming than the identified reference in comparable trials. A small or inconsistent difference can leave the result inconclusive. There is no numeric thermal pass mark.

P1-B1. Name the performance aim and three resource/size constraints. What result would leave the thermal claim inconclusive?

P1-B2. Predict how P1 might compare with P0. Explain why water might still warm in either cup.

P1-P: assemble and label

Teacher supplies three identical stable rigid plastic cups: P0, P1 and P2. Nominal capacity 250–300 mL; approximately straight sides, 7.5 cm internal diameter, 8 cm tall and a broad flat base at least 6 cm across. Each has an identical loose-fitting plastic cover with a factory-made opening/slot for a supported probe. Covers are not sealed or pressurized. The teacher checks that the probes fit without cutting.

Put P0 and P1 in separate marked positions in one dry spill tray, about 15 cm apart, away from sunlight, vents and electrical equipment. Keep them there during a run.

Wrap one dry 26 × 6 cm sheet around P1. Center it vertically: approximately 1 cm of wall remains bare above and below. Overlap the seam; use two pre-cut 5 cm tape strips to hold the sleeve. Keep P0 bare. Leave both cup bases directly on the same tray surface.

Fit identical covers. Support probes vertically through the existing slots using the teacher-supplied holder. The sensing region must be fully immersed, centered horizontally, with its tip 1.5 cm above the inner base, not touching any wall or base. Mark/check insertion depth with the teacher.

Text equivalent of the setup: left and right cup on one level tray; equal water depth; identical covers and centered probes; P0 bare; P1 sleeve around side wall only. Probe displays remain dry and readable.

P1-P1. Draw or describe the assembled pair. Label the sleeve, exposed base/top, water, cover and probe location. Explain one condition that must match.

P1-M: run a matched pair

Use two suitable non-glass liquid probes with 0.1 °C displays, checked by the teacher for water immersion, temperature range and response instructions. Display steps do not establish accuracy. A separate classroom instrument records room air at cup height.

Standard conditions: room air 20–24 °C; common gently mixed cool-water batch 12–14 °C. Measure 150 mL into each cup using the same marked measure, within 2 mL. No ice goes into cups. Record the actual conditions.

Put probes at the marked depth and covers in place. Wait for the teacher-checked response interval (at least 60 seconds). Read both. Starts must differ by no more than 0.5 °C, both be 12–14 °C, and room must be at least 6 °C warmer. If not, keep the readings, mark a failed start, and ask for a fresh matched pair.

When both starts qualify, record both 0-minute readings and the actual clock time; start the timer. Record both probes at 5 and 10 minutes, within 15 seconds of each other and the target time. Record actual time if late. Keep probes in place; do not stir, move cups, lift covers or handle sleeves during a run.

Record room air at 0 and 10 minutes, missing readings, spills, movement and wet sleeves. A room shift over 1 °C, a missing 0/10 reading or a changed procedure flags an inconclusive comparison; retain it and repeat with fresh water if time permits.

After each run, retain the reading sheet. Teacher drains cups, checks sleeve dryness, and conditions cup interiors with 150 mL room-temperature water for 5 minutes. Drain and dry interiors before fresh cool water. Keep sleeves assembled and dry between runs; log any rebuild. Three timepoints are ONE trial. Three trials require three fresh water pairs.

P1-C: instruments and trial order

Before each phase, the teacher places probes A and B together in stirred common water, first at room-water temperature and then at cool-batch temperature. Hold equal immersion depths without contact. Wait the maker's response interval and at least 60 seconds; then read twice 30 seconds apart. Each probe must change no more than 0.2 °C between these readings and their displayed readings must differ no more than 0.5 °C. If not met within 2 minutes after the minimum response interval, replace/check equipment or use supplied data. Record all readings.

This is a consistency/response check, not calibration or proof of accuracy. Do not silently correct readings by subtracting an assumed offset. Repeat the check after the phase; a new disagreement flags possible drift.

First comparison order: F1: P0 left/A, P1 right/B. F2: P0 right/B, P1 left/A. F3: P0 left/A, P1 right/B. Labels follow cups, not position. Teacher moves empty cups and swaps probes between trials, never during a run. This reduces a one-position or one-probe explanation but three trials do not perfectly balance everything.

P1-C1. A reads 13.0 °C and B reads 13.7 °C in the same mixed water after settling. Should the pair start? What does a 0.1 °C display tell you?

P1-C2. Why swap positions/probes between fresh trials? Why are 0, 5 and 10 minutes not three independent trials?

P1-C: instrument-check record

BLANK empirical form. Use one copy for each group/phase, or attach a clearly identified teacher-recorded check for your exact probes. Follow P1-C. Keep before and after values. This checks consistency and response, not calibration.

P1-C3. Record group/date/phase and check-record ID; probe A/B maker/model/IDs; teacher-checked immersion/response instructions and required wait; classroom air instrument ID/location. Record any supplied maker accuracy information as stated, or “not available”; do not infer it from display resolution.

P1-D-BLANK-CHECK: BLANK empirical form; °C readings, wait in seconds; second read 30 s after first.

Blank empirical instrument-check record; no readings supplied.

Check water	A read1 °C	B read1 °C	A read2 °C	B read2 °C	Wait s
Before: room					
Before: cool					
After: room					
After: cool					

Record actual check timestamps, conditions, replacement instrument IDs and action here or on an attached named note. Link every run to its check ID. If instruments are replaced mid-phase, use a new check record and fresh samples.

P1-F1: fresh paired trial 1

Blank empirical record. Run F1; reference: P0 bare; prototype: P1 one dry felt sheet. Use P1-M and P1-C. Record °C exactly as displayed; never invent a missing reading.

P1-F1-SET. Record group/date; cup and sensor IDs/left-right positions; cover and sleeve condition; measured mL each; common-batch temperature; probe response interval; linked instrument-check record ID (P1-S-DEVICE).

P1-D-BLANK-F1: BLANK empirical record; minutes and °C, actual timestamps required.

Blank empirical recording form: no readings supplied.

Target min	Actual clock	Reference °C	Prototype °C	Room °C	Notes
0	_____	_____	_____	_____	_____
5	_____	_____	_____	—	_____
10	_____	_____	_____	_____	_____

P1-F1-LOG. Record changes, late/missing readings, wet materials, spills or movement, even if the result looks surprising. Mark usable, flagged or failed start; give a reason. Record any fresh replacement run with a new ID.

P1-F2: fresh paired trial 2

Blank empirical record. Run F2; reference: P0 bare; prototype: P1 one dry felt sheet. Use P1-M and P1-C. Record °C exactly as displayed; never invent a missing reading.

P1-F2-SET. Record group/date; cup and sensor IDs/left-right positions; cover and sleeve condition; measured mL each; common-batch temperature; probe response interval; linked instrument-check record ID (P1-S-DEVICE).

P1-D-BLANK-F2: BLANK empirical record; minutes and °C, actual timestamps required.

Blank empirical recording form: no readings supplied.

Target min	Actual clock	Reference °C	Prototype °C	Room °C	Notes
0	_____	_____	_____	_____	_____
5	_____	_____	_____	—	_____
10	_____	_____	_____	_____	_____

P1-F2-LOG. Record changes, late/missing readings, wet materials, spills or movement, even if the result looks surprising. Mark usable, flagged or failed start; give a reason. Record any fresh replacement run with a new ID.

P1-F3: fresh paired trial 3

Blank empirical record. Run F3; reference: P0 bare; prototype: P1 one dry felt sheet. Use P1-M and P1-C. Record °C exactly as displayed; never invent a missing reading.

P1-F3-SET. Record group/date; cup and sensor IDs/left-right positions; cover and sleeve condition; measured mL each; common-batch temperature; probe response interval; linked instrument-check record ID (P1-S-DEVICE).

P1-D-BLANK-F3: BLANK empirical record; minutes and °C, actual timestamps required.

Blank empirical recording form: no readings supplied.

Target min	Actual clock	Reference °C	Prototype °C	Room °C	Notes
0	_____	_____	_____	_____	_____
5	_____	_____	_____	—	_____
10	_____	_____	_____	_____	_____

P1-F3-LOG. Record changes, late/missing readings, wet materials, spills or movement, even if the result looks surprising. Mark usable, flagged or failed start; give a reason. Record any fresh replacement run with a new ID.

P1-R1: fresh paired trial 1

Blank empirical record. Run R1; reference: P1 original one-sheet sleeve; prototype: P2 declared redesign. Use P1-M and P1-C. Record °C exactly as displayed; never invent a missing reading.

P1-R1-SET. Record group/date; cup and sensor IDs/left-right positions; cover and sleeve condition; measured mL each; common-batch temperature; probe response interval; linked instrument-check record ID (P1-S-DEVICE).

P1-D-BLANK-R1: BLANK empirical record; minutes and °C, actual timestamps required.

Blank empirical recording form: no readings supplied.

Target min	Actual clock	Reference °C	Prototype °C	Room °C	Notes
0	_____	_____	_____	_____	_____
5	_____	_____	_____	—	_____
10	_____	_____	_____	_____	_____

P1-R1-LOG. Record changes, late/missing readings, wet materials, spills or movement, even if the result looks surprising. Mark usable, flagged or failed start; give a reason. Record any fresh replacement run with a new ID.

P1-R2: fresh paired trial 2

Blank empirical record. Run R2; reference: P1 original one-sheet sleeve; prototype: P2 declared redesign. Use P1-M and P1-C. Record °C exactly as displayed; never invent a missing reading.

P1-R2-SET. Record group/date; cup and sensor IDs/left-right positions; cover and sleeve condition; measured mL each; common-batch temperature; probe response interval; linked instrument-check record ID (P1-S-DEVICE).

P1-D-BLANK-R2: BLANK empirical record; minutes and °C, actual timestamps required.

Blank empirical recording form: no readings supplied.

Target min	Actual clock	Reference °C	Prototype °C	Room °C	Notes
0	_____	_____	_____	_____	_____
5	_____	_____	_____	—	_____
10	_____	_____	_____	_____	_____

P1-R2-LOG. Record changes, late/missing readings, wet materials, spills or movement, even if the result looks surprising. Mark usable, flagged or failed start; give a reason. Record any fresh replacement run with a new ID.

P1-R3: fresh paired trial 3

Blank empirical record. Run R3; reference: P1 original one-sheet sleeve; prototype: P2 declared redesign. Use P1-M and P1-C. Record °C exactly as displayed; never invent a missing reading.

P1-R3-SET. Record group/date; cup and sensor IDs/left-right positions; cover and sleeve condition; measured mL each; common-batch temperature; probe response interval; linked instrument-check record ID (P1-S-DEVICE).

P1-D-BLANK-R3: BLANK empirical record; minutes and °C, actual timestamps required.

Blank empirical recording form: no readings supplied.

Target min	Actual clock	Reference °C	Prototype °C	Room °C	Notes
0	_____	_____	_____	_____	_____
5	_____	_____	_____	—	_____
10	_____	_____	_____	_____	_____

P1-R3-LOG. Record changes, late/missing readings, wet materials, spills or movement, even if the result looks surprising. Mark usable, flagged or failed start; give a reason. Record any fresh replacement run with a new ID.

P1-A: compare the first trials

Use your F1–F3 records, or the constructed first-comparison records P1-S-CASE1. Temperature rise = 10-minute reading minus 0-minute reading. For each usable pair, compare the two rises; a smaller rise means less warming during that interval.

P1-A1. Make a table listing each run ID, reference rise, P1 rise and the difference (reference rise minus P1 rise). Include flags; do not combine flawed and usable trials silently.

P1-A2. Make a bounded claim using all three pairs. Identify one limit. You may use a table instead of a graph.

P1-A3. Would this comparison show that felt alone caused the difference? State what is compared and one further test.

P1-R: commit to a redesign

Retest P2 AGAINST P1, the original one-sheet dry felt prototype, not against P0 and not against an old reading. Keep P1 assembled and dry. Build P2 on the third identical cup. P2 may have one or two supplied sheets; total ≤ 30 cm tape, footprint ≤ 12 cm diameter, height ≤ 9 cm. Keep base/top/slot exposed. Teacher checks stability and probe placement.

Use the same fresh-pair method P1-M and consistency check P1-C. R1: P1 left/A, P2 right/B; R2: P1 right/B, P2 left/A; R3: P1 left/A, P2 right/B. Preserve P1 as the concurrent reference. Keep P2 assembled between runs; log any change.

P1-R-PLAN. Before seeing retest results, specify P2's materials, dimensions and tape total. State your prediction, named reference and controls. If using supplied data, propose a design first; the later record is for the specified fictional P2, not your proposal.

P1-R-REF. Why is comparing today's P2 only with yesterday's P1 endpoint weaker than concurrent retesting?

P1-D: supplied first-comparison record

CONSTRUCTED FICTIONAL RECORDS. Author-created for analysis; no physical run or computational simulation produced these values.

Shared conditions: identical described cups/covers, 150 mL each, dry one-sheet P1, probes as scheduled, minimum response 60 s. Fictional consistency checks: room A/B22.0/22.1 then 22.0/22.1 °C; cool 13.0/13.1 then 13.0/13.1 °C before and after phase. No spills or movement. Starts/clock/room readings appear below; date: fictional Day 1.

F1 P0 left/A; P1 right/B. F2 P0 right/B; P1 left/A. F3 P0 left/A; P1 right/B. Each run used fresh water after the stated room-water reset.

P1-D-CASE-F1: constructed F1; reference P0, prototype P1; no anomalies.

Constructed teaching data: these values were invented for this activity, not collected in an experiment. Not computationally simulated.

Minute	Clock	Reference °C	Prototype °C	Room °C
0	09:00	13.0	13.1	22.0
5	09:05	14.6	14.3	—
10	09:10	16.0	15.3	22.2

P1-D-CASE-F2: constructed F2; reference P0, prototype P1; no anomalies.

Constructed teaching data: these values were invented for this activity, not collected in an experiment. Not computationally simulated.

Minute	Clock	Reference °C	Prototype °C	Room °C
0	09:20	13.2	13.0	22.1
5	09:25	14.9	14.3	—
10	09:30	16.4	15.4	22.2

P1-D-CASE-F3: constructed F3; reference P0, prototype P1; no anomalies.

Constructed teaching data: these values were invented for this activity, not collected in an experiment. Not computationally simulated.

Minute	Clock	Reference °C	Prototype °C	Room °C
0	09:40	12.9	13.0	22.2
5	09:45	14.5	14.2	—
10	09:50	16.0	15.3	22.2

P1-D: supplied redesign/retest record

CONSTRUCTED FICTIONAL RECORDS. These belong to the specified fictional P2, not to a learner's unbuilt redesign.

Fictional P2: two 26 × 6 cm felt sheets, each 2 mm thick, 20 cm tape, footprint 9 cm diameter, height 8 cm; base/top/slot exposed. P1 reference: original single-sheet sleeve, unchanged. 150 mL each; identical cups/covers/probe placement; 60 s minimum response; fresh water and room-water reset each run. Day 2.

R1 P1 left/A, P2 right/B; R2 P1 right/B, P2 left/A; R3 P1 left/A, P2 right/B. Fictional room/cool consistency readings before/after: same as Day 1. R2: a spill wet P2's outer sleeve near 2 min; retained, flagged. Teacher replaced it with identical dry material for R3, recorded rebuild; R3 is not an unchanged uninterrupted sequence.

P1-D-CASE-R1: constructed R1; reference P1, prototype P2; dry.

Constructed teaching data: these values were invented for this activity, not collected in an experiment. Not computationally simulated.

Minute	Clock	Reference °C	Prototype °C	Room °C
0	10:00	13.0	13.1	22.0
5	10:05	14.2	14.1	—
10	10:10	15.3	15.0	22.1

P1-D-CASE-R2: constructed R2; WET-SLEEVE FLAG; retained.

Constructed teaching data: these values were invented for this activity, not collected in an experiment. Not computationally simulated.

Minute	Clock	Reference °C	Prototype °C	Room °C
0	10:20	13.0	13.0	22.1
5	10:25	14.3	14.5	—
10	10:30	15.4	15.7	22.2

P1-D-CASE-R3: constructed R3; rebuilt dry P2; change logged.

Constructed teaching data: these values were invented for this activity, not collected in an experiment. Not computationally simulated.

Minute	Clock	Reference °C	Prototype °C	Room °C
0	10:40	13.1	13.0	22.2
5	10:45	14.3	14.1	—
10	10:50	15.4	15.0	22.2

P1-A: reassess the redesign

Use your R1–R3 records or P1-S-CASE2. Keep the wet/changed/missing records visible. Compare P2 with concurrent P1, using the rises for each pair.

P1-A4. List each reference rise, redesign rise, difference and flag. Does the evidence support improvement? What should happen to an awkward result?

P1-A5. Check the redesign’s resource constraints. Write a revised claim and one exact next comparison.

P1-E: evidence and explanation

P1-E1. Explain why a sleeve could slow warming without making the water colder or stopping all energy transfer. What can the temperature readings tell you?

P1-E2. Give two limits of your claim. Distinguish trial variation, display resolution and instrument accuracy.

P1-E3. Optional graph or table: represent one paired trial’s 0/5/10-minute readings. Label units and run ID; mark any anomaly. Explain one pattern using the representation.

P1-L: a fresh later check

CONSTRUCTED FICTIONAL CASE. New data for reasoning, not a measured classroom result.

A new class compared a dry redesign Z with reference Y using identical cups and 150 mL each in 22 °C air. Suitable probes passed the stated consistency check. Their starts were Y = 12.0 °C and Z = 14.0 °C. After 10 min they read Y = 15.0 °C and Z = 16.0 °C. The class wrote: “Z is better because it rose only 2 °C.” They then read the same cups at 15 and 20 min and claimed three trials.

P1-D-LATER · New comparison

Constructed teaching data: these values were invented for this activity, not collected in an experiment.

Setup	Start °C	After 10 min °C
Y	12.0	15.0
Z	14.0	16.0

P1-L1. Calculate the 10-minute rises. Assess both claims and propose the next usable trial.