

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.

The original sleeve uses one supplied 26 cm × 6 cm felt sheet, at most 3 mm thick. Baseline bare cup has no sleeve. The redesigned sleeve 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.

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

2. Predict how original sleeve might compare with bare cup. Explain why water might still warm in either cup.

assemble and label

Use the three matching cups and loose covers checked and supplied by your teacher: one bare reference, one original sleeve and one redesign. The teacher checks that supported probes fit through the existing slots without cutting. Covers stay loose, not sealed or pressurized. Ask the teacher if the sleeve does not wrap with overlap or the sensing region cannot stay fully immersed at the marked depth.

1. Put bare cup and original sleeve 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.
2. Wrap one dry 26×6 cm sheet around the cup used for the original sleeve. 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 the reference cup bare. Leave both cup bases directly on the same tray surface.
3. 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; bare cup; original sleeve around side wall only. Probe displays remain dry and readable.

Check the apparatus before starting

Matching loose covers; existing probe slots

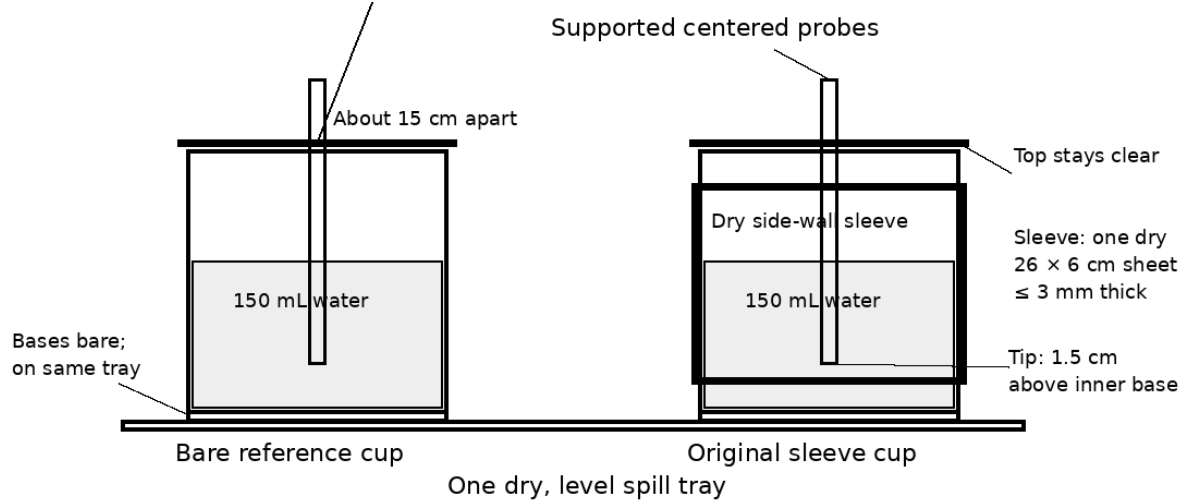


Diagram is schematic, not to scale. Keep the bases, top covers, probe slots and displays uncovered. Ask the teacher to check fit and insertion depth.

Draw your pair below, or describe it using a response method your teacher offers. Label water, sleeve, cover, probe and exposed base; explain one condition that must match.

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.

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 $0.2\text{ }^{\circ}\text{C}$ between these readings and their displayed readings must differ no more than $0.5\text{ }^{\circ}\text{C}$. 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: bare cup left/A, original sleeve right/B. F2: bare cup right/B, original sleeve left/A. F3: bare cup left/A, original sleeve 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.

1. A reads $13.0\text{ }^{\circ}\text{C}$ and B reads $13.7\text{ }^{\circ}\text{C}$ in the same mixed water after settling. Should the pair start? What does a $0.1\text{ }^{\circ}\text{C}$ display tell you?

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

commit to a redesign

Retest redesigned sleeve AGAINST original sleeve, the original one-sheet dry felt prototype, not against bare cup and not against an old reading. Keep original sleeve assembled and dry. Build redesigned sleeve on the third identical cup. redesigned sleeve 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 fresh-pair method and consistency check on the Instruments and Trial Order page. R1: original sleeve left/A, redesigned sleeve right/B; R2: original sleeve right/B, redesigned sleeve left/A; R3: original sleeve left/A, redesigned sleeve right/B. Preserve original sleeve as the concurrent reference. Keep redesigned sleeve assembled between runs; log any change.

1. Before seeing retest results, specify redesigned sleeve'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 redesigned sleeve, not your proposal.

2. Why is comparing today's redesigned sleeve only with yesterday's original sleeve endpoint weaker than concurrent retesting?
