LAB L9.3: THE THERMAL CONDUCTION RACE

TODAY'S JOB

Five rods — copper, aluminum, brass, glass, and wood — stand in one cup of hot water, each carrying an identical butter dab the same height above the waterline. The rod whose dab slumps first passed energy up its length fastest. By the end of the period, your group will have a data-backed ranking of the five materials as thermal conductors, and a written argument (claim–evidence–reasoning) defending that ranking.

WARMUP **Retrieval — yesterday's physics runs today's race**

(a) A copper rod at 22 °C stands in an 85 °C water bath. Circle the direction energy transfers as heat: **bath → rod** / **rod → bath**. What difference between the bath and the rod drives that transfer?

_____

(b) After a long soak, the rod's lower end and the bath stop exchanging net energy. Circle the quantity that is then EQUAL for the rod's lower end and the bath: **temperature** / **thermal energy**. In one line, why is the other quantity not equal?

_____

(c) Rest one palm on your metal chair frame and the other on the wooden desktop. Both sat in this room all night. Circle your prediction — the metal's temperature is: **lower than / equal to / higher than** the wood's temperature. Keep your answer; page 4 comes back to your hands.

CONDUCTION — THE MECHANISM YOU'RE RANKING

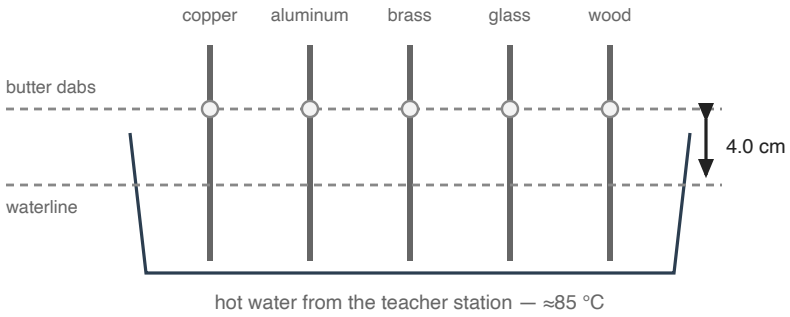
The bath's molecules collide with the rod's submerged end, and the particles there gain kinetic energy. Those particles collide with their neighbors, the neighbors collide with theirs, and the energy is handed up the rod collision by collision. This is **conduction**: like a bucket brigade, the energy (the water) moves down the line while the particles (the people) stay near their places.

Different materials hand energy along at very different rates. A butter dab slumps when its temperature reaches roughly 30–35 °C, so each dab is a finish line: the melt time records how quickly its rod delivered the melt energy. Shorter melt time, better conductor.

Safety — hot water scalds. Your teacher pours the ≈85 °C water. Goggles on. Treat the lower half of every metal rod as hot: handle rods only above the dab line, or with tongs. Wipe spills right away — a wet floor is a slip hazard.

Notes / reasoning

APPARATUS — THE STARTING GRID



The starting grid: five rods, one shared bath, every dab 4.0 cm above the waterline.

Per group: copper, aluminum, brass, glass, and wood rods (same length and diameter); pre-formed butter dabs; foam cup with fill line; thermometer; stopwatch; tongs; goggles; paper towels.

PROCEDURE — GIVEN TODAY; THE ANALYSIS IS YOURS

1. Check each rod: one equal-size butter dab centered on the mark 4.0 cm above where the waterline will sit. Re-form any dab that smeared in the tray.
2. **Before any water pours**, agree as a group on the exact moment that counts as "melted" (example: the dab first slumps and starts to run). Write your group's criterion:

   _____
3. Your teacher fills the cup with hot water to the fill line. Record the bath temperature for the trial in the data table on page 3.
4. Stand all five rods in the cup **at the same moment** and start the stopwatch.
5. Record the melt time of each dab against your group's criterion. When the 60 s window ends, record ">60" for every dab still holding its shape.
6. Dry the rods and swap them for the room-temperature spare set (used rods go to the cooling rack). Re-dab and run trials 2 and 3 the same way, with fresh hot water each time.

Why the fussy setup: same dab size, same 4.0 cm height, one shared bath, one shared start. Every rod faces the same challenge, so a difference in melt times points at the material — not at the setup.

Notes / reasoning

DATA

Bath temperature: Trial 1: _____ °C Trial 2: _____ °C Trial 3: _____ °C

Rod	Melt time, trial 1 (s)	Melt time, trial 2 (s)	Melt time, trial 3 (s)	Mean (s)
copper				
aluminum				
brass				
glass				
wood				

A ">60" is not a number — a dab that never melted has *no* melt time to average. If any trial of a rod reads ">60", write ">60" for that rod's mean as well.

UNCERTAINTY How Sure Are Your Times?

(a) Two things blur every melt time: stopwatch reflexes and judging the moment your criterion was met. Estimate a ± value for your group's melt times, and justify the value in one line:

± _____ s, because _____

(b) Write your two fastest rods' mean melt times as ranges. (Example of the form: 30 ± 2 s means "28 s to 32 s.")

Rod _____: from _____ s to _____ s Rod _____: from _____ s to _____ s

(c) Circle one: the two ranges **overlap / do not overlap**. In one line: does your data settle the order of these two rods, or could the ± be responsible for which mean came out smaller?

_____

COMPUTE 1 How Much Faster Is First Place?

Every dab was identical, so every dab needed the same energy to melt. Divide the mean melt time of your **3rd-place metal** by the mean melt time of your **1st-place metal**, carrying the units through the division:

ratio = _____ s ÷ _____ s = _____ (the seconds cancel — a pure number)

On average, the 1st-place rod delivered the melt energy _____ times faster than the 3rd-place rod.

COMPUTE 2 Percent Uncertainty of the Winner

For your fastest rod, compute the percent uncertainty of its mean melt time, using your ± value from Uncertainty (a). Show the units canceling.

percent = (_____ s ÷ _____ s) × 100% = _____ %

ANALYSIS — CLAIM · EVIDENCE · REASONING

CLAIM Rank the Five Rods as Thermal Conductors

Best conductor to worst. Use ">" between rods your data separates, and "≈ (can't tell)" wherever the data leaves a tie.

EVIDENCE Cite the Numbers

Quote the mean melt times (with units), your ± value, and the ">60" window records that support each link in your ranking — including any tie.

REASONING Connect Evidence to Claim

Explain why a shorter melt time on an identical dab means a better conductor. Name at least two things the procedure held the same across rods, and state what each control rules out.

DESIGN The Tie at the Bottom

(a) Glass and wood both read ">60 s". In one line: can this data set decide which of glass and wood conducts better?

_____

(b) Propose ONE change to the procedure that would break the glass–wood tie, and name one variable your change must still hold the same for the comparison to stay fair.

WRAP-UP Back to Your Hands

A thermometer taped to the metal chair frame and another taped to the wooden desktop read the SAME temperature after a night in the same room — yet the metal felt colder in Warmup (c). Using your ranking, explain in 2–3 sentences what your palm actually reports when the metal "feels colder."