

Pick the Spoon: Property Data Decides

Investigation question: A kit for melting candle wax and chocolate needs a stirring spoon. Seven materials are available. Which one should the company choose, and how do you decide fairly when no material is perfect?

Data-driven decision

Groups of 4

1 session

Setup 6 · Activity 40 · Cleanup 6 min

MS-PS1-2 · practice

MS-ETS1-2 · practice

MS-ETS1-3 · practice

Name

Group

Date

Your role today

- ☐ **Data lead:** Reads each property from the table aloud, computes spoon mass and cost for each candidate, and checks the arithmetic of the others.
- ☐ **Screenener:** Applies the three must-pass criteria to each candidate, records pass or fail with the property that caused the fail, and keeps the list of survivors.
- ☐ **Scorer:** Scores the survivors on the four scored criteria using the group's agreed scale and totals the matrix.
- ☐ **Station tester:** Runs the verification station: measures mass and volume for the four samples, records what the hot-water test does, and reports back whether the table values held up.

Safety

- The hot-water station is teacher-operated only. Water at 80 °C scalds instantly; students observe from arm's length and never pour, reach into or move the container. Use tongs for every sample.
- Keep the hot-water container on a tray away from the bench edge and away from cords and backpacks.
- Steel bolts dropped into a glass cylinder can crack it; lower them in with the cylinder tilted, or use a plastic cylinder.
- Pine dust and wax shavings can irritate eyes; brush samples off the bench into the waste, not onto the floor.
- No flames anywhere. The flammability column in the table comes from reference information, not from a demonstration.
- Wipe up water spills at once; wet floors near a balance table are a slip hazard.

Procedure

1. Read the design brief on the recording sheet: the spoon will rest in a pot of melted wax or chocolate at up to 90 °C, be washed in hot soapy water, sit near a stove burner, have a volume of about 30 cm³, and be sold in a low-cost kit. Underline every requirement.
2. Data lead: for each of the seven materials, compute the spoon's mass (density × 30 cm³) and its material cost (mass in kg × cost per kg). Write both in the screening table.

3. Screener: apply the three must-pass criteria to every material. Criterion 1: must not melt or soften below 120 °C. Criterion 2: must not dissolve in hot water or soak up enough water to swell or stay damp (a material that absorbs only a little, like nylon, passes; wood does not). Criterion 3: spoon mass must be 250 g or less. Mark pass or fail for each and write which property caused any fail. A material that fails any one criterion is out, no matter how good it is elsewhere.
4. Scorer: for the survivors only, score four criteria from 3 (best) to 1 (worst): lighter is better, cheaper is better, not burning in a stove flame is better, and a handle that stays cool (does not conduct heat quickly) is better. Total the scores.
5. Station tester (while steps 2 to 4 run): measure the density of the steel bolts, the PP caps and the wax chunk by water displacement in the 100 mL cylinder (push floating samples fully under with the wire; read the rise). Measure the pine block with the ruler instead (length × width × height) because it soaks up water. Weigh each sample and compute density; compare with the table.
6. When called, bring the PP cap and the wax chunk to the teacher's hot-water station. Watch for two minutes as the teacher places both in 80 °C water with tongs. Record what happens to each.
7. As a group, compare the station results with the table. Did the measured densities match within about 0.1 g/cm³? Did the hot-water test agree with the melting or softening column?
8. Decide. Write the group's recommended material, the two strongest reasons from the data, and the trade-off the chosen material still has. Then sketch a two-material spoon that fixes that trade-off, labeling which material goes where and which property of each you are using.
9. Clean the station: dry the samples, return them to the kit, empty and rinse the cylinder, wipe the bench. Answer the analysis questions individually.

Record your observations

Lab 2 recording sheet: Pick the spoon

Design brief — A company sells a kit for melting candle wax and chocolate in a pot on the stove. The kit needs a stirring spoon. The spoon rests in melted wax or chocolate at up to 90 °C, is washed afterward in hot soapy water, sits beside a stove burner, has a volume of about 30 cm³, and must keep the kit cheap. Choose the material.

Property data for seven candidate materials (rounded teaching values)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Material	Density (g/cm ³)	Melts or softens at (°C)	Dissolves in or soaks up water?	Burns in a stove flame?	Conducts heat quickly?	Cost (\$ per kg)
Aluminum	2.70	660	No	No	Yes	3
Stainless steel	7.9	about 1400	No	No	Yes, but slower than aluminum	4
Polypropylene (PP)	0.90	about 160	No	Yes	No	2
PLA plastic	1.24	softens about 60	No	Yes	No	4
Nylon	1.14	about 220	Soaks up a little	Yes	No	5
Pine wood	0.50	does not melt; chars above about 250	Soaks up water	Yes	No	1
Paraffin wax	0.90	about 55	No	Yes	No	2

This is a teaching dataset: densities and temperatures are rounded from reference values, and the costs are rough approximations that change with the market.

Step 1: screen every material (must-pass criteria)

Material	Spoon mass (g) = density × 30	Cost per spoon (\$)	C1: stays solid above 120 °C?	C2: no dissolving or soaking?	C3: mass 250 g or less?	Still in? (property that failed, if any)
Aluminum						
Stainless steel						
Polypropylene (PP)						
PLA plastic						
Nylon						
Pine wood						
Paraffin wax						

Step 2: score the survivors (3 = best, 2 = middle, 1 = worst)

Surviving material	Lighter is better	Cheaper is better	Does not burn is better	Cool handle (poor heat conductor) is better	Total

Verification station: does the table hold up?

Sample	Mass (g)	Volume method (water rise or ruler)	Volume (cm ³)	Measured density (g/cm ³)	Table value	Within 0.1?
Steel bolts					7.9	
PP caps					0.90	
Pine block					0.50	
Wax chunk					0.90	

Hot-water test (teacher station, about 80 °C, two minutes)

Sample	Before	After 2 minutes	Agrees with the 'melts or softens' column?
PP cap			
Wax chunk			

- Our recommendation: name the material, give the two strongest reasons from the data, and state the trade-off this material still has.

2. Which material was eliminated by the screen even though it had the best score on at least two of the scored criteria? Which property eliminated it?

-  Sketch a spoon made of two materials that fixes your recommended material's trade-off. Label which material forms the bowl and which forms the handle, and next to each label write the property from the table that you are using.

Analysis questions

3. Show the calculation for the stainless steel spoon's mass and its material cost. Does it pass criterion 3?

4. Why does the process screen on must-pass criteria before scoring? Give an example from this lab of a material that would have ranked near the top if it had been scored without screening.

5. Pine wood is the lightest and cheapest material in the table, yet it was eliminated. Which property eliminated it, and why does that property matter for a spoon that is washed in hot soapy water?

6. At the station, which sample's measured density was farthest from the table value? Suggest a reason connected to how you measured its volume.

7. In 80 °C water the wax melted but the polypropylene cap did not change. Which property did that test check? Predict, with a reason, what PLA plastic would have done in the same water.

8. A classmate argues: 'Stainless steel is best because it has the highest melting point.' Use the full screen-then-score process to explain what this argument gets right and what it leaves out, and say what the two-material spoon in your drawing is trying to fix.
