

Save the Ice Cube: Design, Test and Improve an Insulated Holder

Investigation question: How can you use everyday materials to slow the energy flowing from a warm room into an ice cube, so that as little of it as possible melts in 25 minutes?

Engineering design challenge

Groups of 4

2 sessions

Setup 5 · Activity 95 · Cleanup 10 min

MS-ETS1-3 · assesses

MS-PS3-3 · practice

MS-ETS1-1 · practice

MS-PS1-4 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Project manager:** Keeps the group on the clock and inside the 10-point budget, checks the design against every criterion and constraint, and gets the teacher's initials before building.
- ☐ **Builder:** Leads construction, makes sure the holder fits the size box and can be opened and closed in under 30 seconds.
- ☐ **Tester:** Tares the scale, weighs each puck at the start and end, runs the 25-minute timer, and pours off meltwater the same way every time.
- ☐ **Data analyst:** Computes mass lost and percent lost for the design and the control, posts results on the class chart, and leads the comparison of class data.

Safety

- Scissors can cut: cut away from your body and hand scissors over handle first. Foil edges can also cut fingers.
- Freezer-cold ice can stick to skin. Move the puck with its portion cup or a spoon, not with bare fingers for long.
- Water on the floor is a slip hazard and water on a scale can ruin it. Pour meltwater only into the waste cup over a paper towel.
- Do not eat any material: some packing peanuts are made of cornstarch and look like snacks but are not food.
- No heat sources, salt, extra ice, cold packs or refrigerators: they break the constraints and some, such as salt on ice, can make surfaces cold enough to injure skin.

Procedure

1. Session 1. Read the design brief. As a group, rewrite each criterion and constraint as a measurable target (q1). The project manager posts them where everyone can see.
2. Each member sketches one idea for three minutes. The group chooses or combines ideas, draws version 1 with labeled materials and arrows showing where energy could enter the ice (drawing), and adds up the cost. Get the teacher's initials before taking materials.

3. Build version 1 in 12 minutes. Check that it fits the size box and that the puck's cup can be taken out and put back within 30 seconds.
4. Start test 1. The tester sets an empty 3-oz cup on the scale, tares it, pops a puck from its portion cup into the 3-oz cup and records the start mass. The cup goes into the holder and the holder is closed. At the same time a second puck is weighed into a bare 3-oz cup and set uncovered beside it as the control. Start the 25-minute timer and record the room temperature.
5. While you wait, do not open the holder. Answer q2 and write a prediction of your design's percent lost.
6. At 25 minutes, take out the design's cup and the control. For each, hold the puck back with the spoon and tip the cup over the waste cup for five seconds to pour off the meltwater, without blotting. Weigh the cup and puck again (the scale is still tared for an empty cup) and record the end mass. Calculate mass lost and percent lost for both (q3).
7. Session 2. Post your round 1 results on the class chart: main features, cost, your design's percent lost and your control's percent lost. Answer q4 and, as a class, rank the designs by how their percent lost compared with their own control.
8. Study the class chart and answer q5: which features do the best three designs share, and what do the weakest three have in common? Then plan version 2, combining features from at least two other groups' designs, within the 10-point budget (q6). Modify or rebuild in 12 minutes.
9. Run test 2 exactly as test 1, with a new puck and a new bare control. While you wait, answer q8 to q11.
10. Weigh, calculate and post your round 2 results. Compare version 2 with version 1 (q7). Return reusable materials to the supply bins and put trash in the right bins.

Record your observations

Lab 3 recording sheet: Save the ice cube

Design brief. A food-truck owner needs a cheap holder that keeps ice from melting while a customer waits. Your holder must keep a 15 g ice puck from melting for as long as possible at room temperature. **Criteria:** (1) in 25 minutes the puck loses less than one third of the percent that a bare puck loses in the same round; (2) the puck can be taken out and put back within 30 seconds. **Constraints:** a budget of 10 points from the menu; the holder fits inside a 12 cm cube; the puck stays in the 3-oz cup; no added cold (no extra ice, salt, cold packs or refrigerator) and no electricity; 12 minutes to build.

Material menu

Material	Amount	Cost (points)
Aluminum foil	30 cm × 30 cm	1
Newspaper	2 sheets	1
Paper towels	3 sheets	1
Plastic wrap	30 cm	1
Cotton balls	15	2

Material	Amount	Cost (points)
Felt or fleece	20 cm × 20 cm	2
Bubble wrap	20 cm × 30 cm	2
Packing peanuts	1 cup	2
Small cardboard box or paper cup	1	2
Foam cup with lid	1	4
Masking tape, rubber bands	as needed	0

1. Rewrite each criterion and constraint as a target you could check with a measurement or a yes/no test. Which one will be hardest to meet, and why?

-  Sketch version 1 from the side, as if cut in half. Label every material and its thickness. Draw arrows showing every path by which energy from the room could reach the ice (through the sides, top and bottom), and circle the path you think your design blocks least well. Write the total cost.

2. For each material in your design, write the scientific reason you chose it (for example, what it traps, blocks or reflects).

Our test results

Test	Start mass (g)	End mass (g)	Mass lost (g)	Percent lost (%)
Round 1: our design				
Round 1: bare control				
Round 2: our design				
Round 2: bare control				

Class results, round 1

Group	Main features	Cost	Design % lost	Control % lost
1				
2				
3				
4				
5				
6				
7				
8				

Analysis questions

3. Show how you calculated the percent lost for your round 1 design and your round 1 control. (Example: a puck that starts at 15.0 g and ends at 13.8 g lost 1.2 g, and $1.2 \div 15.0 \times 100 = 8$ percent.)

4. Did version 1 meet criterion 1? Show the comparison with one third of your control's percent lost.

5. Use the class chart. Which features did the three best designs share? What did the three weakest designs have in common, or lack? Name the groups you are comparing.

6. Describe version 2. Which features did you combine, from which groups' designs, and why do you expect each one to help? Show that it stays within 10 points.

7. Compare version 2 with version 1, using each round's percent lost and its control. Did combining features help? If not, suggest a reason and a next change.

8. A student says, 'Wrapping the ice in a fleece scarf will make it melt faster, because fleece is warm.' Which response is correct?

- ☐ A. The student is right: fleece gives off heat, so the ice melts faster.
- ☐ B. The student is wrong: fleece makes no energy. It traps still air, which slows the energy flowing from the warmer room into the ice, so the ice melts more slowly.
- ☐ C. The student is wrong: fleece adds cold to the ice, so it melts more slowly.
- ☐ D. Fleece has no effect, because only metals affect how fast energy moves.

- 9.** Use particles to explain why a thick layer of trapped, still air slows the energy reaching the ice better than open room air or direct contact with the table. Then explain why a layer of foil around the outside can also help.

- 10.** Your best design slowed the melting. Did it change the temperature at which the ice melts? Explain what insulation changes and what it does not.

- 11.** Foam cups and packing peanuts often perform well, but most cannot go in a curbside recycling bin. Write one new criterion or constraint that takes this impact into account, and predict how it would change the winning designs.
