

**Erasmus+ Cultural connections : Enhancing EU heritage, Social
Inclusion and Digital Literacy through our Pupils' hearts**
Scientific and Creative Thinking Workshop
7-12 December 2025, Ukmerges, Lithuania



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SCIENTIFIC EXPERIMENT 8.12

Experiment Title

Freezing Water and Expansion: Can Ice Push a Nail Out?

Type of Activity

Hands-on, inquiry-based physical science experiment with visible effects of freezing and material expansion

Grade Level

Ages **10–14** (upper primary / early secondary)

Learning Objectives

Scientific Objectives

Students will be able to:

1. Understand and observe that **water expands when it freezes**.
2. Predict and record physical changes as water transitions from liquid to solid.
3. Measure forces created by expansion.
4. Relate freezing expansion to real-world phenomena (cracks in rocks/asphalt in winter).

Interdisciplinary Objectives

Students will be able to:

- ★ **Physics:** Explain thermal expansion and crystal structure arrangement.
- ★ **Earth Science:** Understand frost weathering and ice pressure in nature.
- ★ **Mathematics:** Quantify force or displacement and compare outcomes.
- ★ **Design / Technology:** Discuss materials and engineering safety (why spaces are left for expansion).

Research Question

What happens to water's volume when it freezes, and can this expansion exert enough force to move a nail embedded in an apple?

Hypothesis

If water expands when it freezes, then placing water around a nail in an apple and freezing it will cause the ice to push the nail upward or outward.

Materials

- Fresh apple
- Clean, straight **nail** (approx. 5–8 cm)
- Plastic cup or small container
- Water
- Freezer
- Ruler or calipers
- Observation notebook

Variables

1. **Independent Variable:** Presence of water freezing around the nail
2. **Dependent Variable:** Movement/displacement of the nail
3. **Controlled Variables:** Same apple size, same water volume, same freezing time, same temperature

Experimental Procedure

1. **Prepare the apple:**
Push the nail into the center of the apple but leave about 1–2 cm exposed at the top. Record initial nail height.
2. **Add water:**
Pour a small amount of water into the apple's core so it surrounds the nail. Ensure it doesn't drip out excessively.
3. **Freezing:**
Carefully place the apple in a small container and put it in the freezer overnight.
4. **Observe changes:**
After freezing, remove the apple and measure the position of the nail again.

- Has the nail moved upward?
 - Measure displacement (in millimeters).
5. **Record and compare:**
Note any deformations of the apple surface and position changes.

Observations

Students should record:

- Whether the nail shifted
- Changes in apple shape
- Any cracking or splitting
- Measurements of nail displacement

Results

Students will likely find that:

1. Ice formation **expands inside the apple**, exerting force outward.
2. The nail may have moved slightly or become tighter/squeezed by the ice.
3. The apple may show cracking or bulging.
This observable force is a direct consequence of **water's unique expansion upon freezing**.

Scientific Explanation

Water molecules form a crystalline lattice when freezing that **occupies a larger volume than liquid water**. Unlike most substances that contract as they solidify, ice expands — by about ~10% — because the rigid structure holds molecules further apart. This volume increase generates pressure on the surrounding material.

Real-World Connections

- ❖ **Frost weathering:** Over winter, water in cracks expands and breaks rocks or asphalt.
- ❖ **Anthropology & engineering:** Expansion must be accounted for in building materials and bridge design.

Conclusion

The experiment shows that freezing water exerts measurable force due to expansion. This property has **practical implications** in nature, construction, and safety.

Interdisciplinary Connections

- **Physics:** Molecular structure and phase changes
- **Earth Science:** Weather effects and erosion
- **Mathematics:** Measuring displacement and comparing data
- **Engineering:** Material design for expansion allowances

Safety Notes

- ★ Use a **plastic container** to avoid breakage in freezer.
- ★ Handle frozen items carefully (cold burns).
- ★ Do not force nail by hand — use measurements only.

Reflection Questions

1. Why does water expand when it freezes?
2. How can this expansion cause damage outdoors in winter?
3. How does this relate to the video where freezing pushed objects?
4. How does ice expansion differ from most materials?

Note: This experiment was inspired by the documentary at <https://www.youtube.com/watch?v=7jDei3xyC60>

Student Observation & Graph Worksheet

Freezing Water: Expansion Forces & Driving a Nail

Name: _____

Date: _____

Class: _____

1. Experiment Title

Freezing Water and Expansion: Can Ice Push a Nail?

2. Research Questions

1. *How does water expansion during freezing generate force?*
2. *Can freezing water in an apple or container push a nail into a soft surface?*

3. Materials Used

Circle all materials you used:

- Fresh apple or small soft block (e.g., foam)
- Nail (approx. 5–8 cm)
- Spoon / knife (for making hole)
- Water
- Freezer
- Small container (to hold apple or block upright)
- Ruler or calipers
- Observation worksheet
- Protective gloves (optional)

4. Prediction (Before the Experiment)

Sample	Prediction: Will nail move?	Reason
Apple + water + nail	<input type="checkbox"/> Yes <input type="checkbox"/> No	_____
Soft block + water + nail	<input type="checkbox"/> Yes <input type="checkbox"/> No	_____

Explain your reasoning:

5. Experimental Procedure

Step 1 – Prepare the sample:

1. Push the nail partway into the apple or soft block (leave 1–2 cm exposed).
2. Make a small cavity around the nail and pour in water.

Step 2 – Freeze:

1. Place the sample upright in a small container.
2. Put it in the freezer for several hours until fully frozen.

Step 3 – Observe nail movement:

1. Remove from freezer carefully.
2. Measure how much the nail has moved upward or driven deeper into a soft surface.
3. Note any cracking or deformation.

Step 5 – Record data:

1. Measure displacement in millimeters.
2. Note observations in table below.

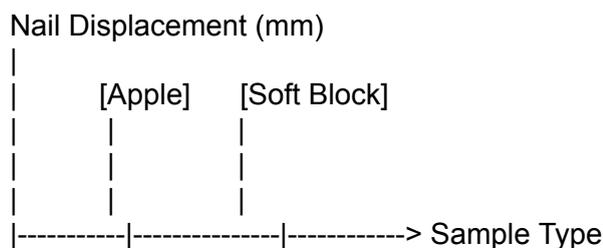
6. Observation Table

Sample	Nail Position Before Freezing	Nail Position After Freezing	Nail Displacement (mm)	Notes / Observations
Apple	_____	_____	_____	_____
Soft block	_____	_____	_____	_____

7. Graphing Activity**Instructions:**

- **X-axis:** Sample type (Apple / Soft Block)
- **Y-axis:** Nail displacement (mm)
- **Bars or points:** Use one color per sample

Optional extension: Compare multiple trials or temperatures.

Example Graph Layout (Sketch):

8. Results Analysis

1. Which sample caused the nail to move more?

2. How does freezing water generate force?

3. Did temperature or the amount of water affect movement?

4. How could this principle be used in real life (nature or engineering)?

9. Scientific Explanation

- Water expands when it freezes by ~10 %.
- This expansion exerts force in all directions.
- Ice in the apple or block can push a nail upward or drive it into a soft material.
- This demonstrates **mechanical work done by freezing water**.

10. Reflection Questions

1. Why does ice expand while most substances shrink when frozen?

2. How could this explain cracks in rocks, roads, or soil during winter?

3. How could engineers prevent damage from freezing water?

11. Conclusion

Complete the sentence:

This experiment shows that freezing water can generate enough force to

_____.

Teacher Notes / Safety

- Use **soft materials** for hammering simulation; do not hit nails into hard surfaces.

- Measure displacement carefully.
- Handle frozen samples carefully to avoid cold burns.
- Ensure group discussion about **real-life applications** (rocks, pipes, engineering).

Experiment Title

Can You Hammer a Nail with an Apple? Testing Normal vs Frozen Temperature

Type of Activity

Hands-on inquiry-based physics experiment demonstrating how **temperature changes affect material hardness** and mechanical force.

Grade Level

Ages **10–14** (upper primary / early secondary)

Learning Objectives

Scientific Objectives

Students will be able to:

1. Compare material hardness at different temperatures.
2. Predict and measure the effect of freezing on the apple's rigidity.
3. Collect, analyze, and interpret quantitative and qualitative data.
4. Relate observations to the physical principle of **freezing water expanding and increasing rigidity**.

Interdisciplinary Objectives

1. **Physics:** Material properties, force, phase change.
2. **Biology:** Water content in fruit, cellular structure.
3. **Engineering / Life Skills:** Understanding mechanical work, safety, and tools.
4. **Mathematics:** Measurement of displacement or penetration depth.
5. **Language / Reflection:** Recording observations, drawing conclusions.

Research Question

Can an apple at room temperature or frozen drive a nail into a soft surface?

Hypotheses

1. A fresh (room temperature) apple is too soft to hammer a nail.
2. A frozen apple is rigid enough to drive a nail partially into a soft surface.
3. Freezing increases rigidity due to the solidification of water inside the apple.

Materials

- Fresh apple(s)

- Small nails ($\approx 5\text{--}8$ cm)
- Soft wood block or foam block (to safely test hammering)
- Freezer
- Ruler or calipers
- Plastic tray or container
- Protective gloves and goggles
- Optional: small mallet for safe tapping simulation

Variables

Type	Variable	Details
Independent	Apple temperature	Room temperature vs frozen
Dependent	Nail penetration / displacement	Measured in mm
Controlled	Apple size, nail size, soft surface, amount of applied force	All kept constant

Experimental Procedure

Step 1 – Prepare Samples

1. Take two apples of similar size.
2. Push the nail slightly into each apple, leaving 1–2 cm exposed.
3. Place one apple in the freezer for several hours until fully frozen.

Step 2 – Prepare Testing Surface

Place a soft wood or foam block on a flat surface.

Step 3 – Test Room Temperature Apple

1. Position the apple above the soft surface.
2. Gently tap the exposed nail with the apple (or simulate hammering safely).
3. Measure and record any nail displacement.

Step 4 – Test Frozen Apple

1. Remove frozen apple from freezer.
2. Repeat the tapping procedure above.
3. Measure and record nail displacement.

Observation Table

Apple Temperature	Nail Penetration (mm)	Notes / Observations
Room temp	_____	Soft apple, nail barely moved
Frozen	_____	Rigid apple, nail moved _____ mm, possible cracking

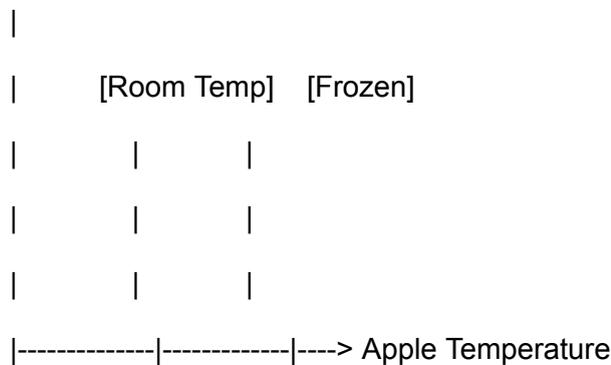
Graphing Activity

Instructions:

1. **X-axis:** Apple temperature (Room vs Frozen)
2. **Y-axis:** Nail penetration (mm)
3. **Bars / points:** Plot nail displacement for each condition
4. Compare results visually

Example Sketch:

Nail Penetration (mm)



Results Analysis

1. Which apple allowed the nail to move farther?
2. How does freezing water inside the apple affect hardness?
3. Did freezing make a measurable difference in the apple's ability to apply force?
4. How does this relate to natural phenomena (e.g., frost splitting rocks)?

Scientific Explanation

Water expands and solidifies inside the apple when frozen.

Frozen water increases the rigidity of the apple's structure.

This makes it possible for the apple to **exert mechanical force** and partially drive a nail into a soft surface.

Reflection Questions

1. Why is the fresh apple too soft to hammer a nail?
2. How could this experiment demonstrate the effects of temperature on material properties?
3. Can you think of any real-life situations where freezing increases rigidity and causes damage?

Safety Notes

- Never hit nails into hard surfaces. Use foam or soft wood.
- Wear gloves and goggles when handling frozen apples.
- Do not eat apples used in the experiment.
- Teacher supervision required.

Conclusion Template

This experiment shows that freezing an apple increases its rigidity, allowing it to exert force on a nail. At room temperature, the apple is too soft, so freezing **changes the material properties**, demonstrating how temperature affects hardness and mechanical work.

Student Observation & Graph Worksheet

Can You Hammer a Nail with an Apple? Room Temperature vs Frozen

Name: _____

Date: _____

Class: _____

1. Experiment Title

Testing Apple Rigidity: Can Freezing Help Hammer a Nail?

2. Research Questions

1. Can a fresh (room temperature) apple drive a nail into a soft surface?
2. Can a frozen apple drive a nail into a soft surface?
3. How does freezing change the mechanical properties of the apple?

3. Hypotheses

Apple Condition	Prediction: Will the nail move?	Reason
Room temperature	<input type="checkbox"/> Yes <input type="checkbox"/> No	_____
Frozen	<input type="checkbox"/> Yes <input type="checkbox"/> No	_____

4. Materials

Circle all materials used:

- Apple (fresh and frozen)
- Small nail (~5–8 cm)
- Soft wood or foam block
- Freezer
- Ruler or calipers
- Plastic tray or container
- Gloves and goggles

5. Procedure Summary

1. Insert a nail into the apple, leaving 1–2 cm exposed.
2. Place one apple in the freezer until fully frozen.
3. Place the apple over a soft surface and gently tap the nail.
4. Measure nail movement in millimeters.
5. Record observations.

6. Observation Table

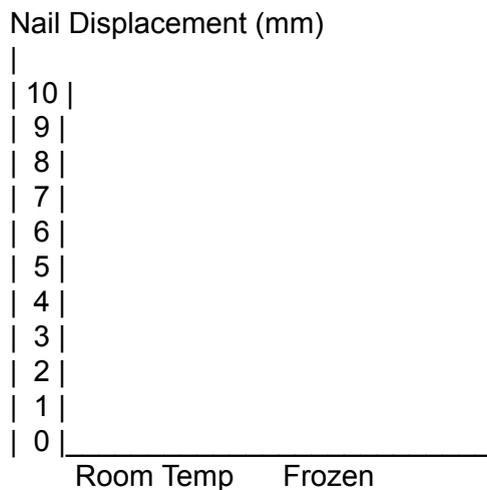
Apple Condition	Nail Position Before (mm)	Nail Position After (mm)	Nail Displacement (mm)	Notes / Observations
Room temperature	_____	_____	_____	_____
Frozen	_____	_____	_____	_____

7. Graphing Activity

Instructions:

- **X-axis:** Apple Condition (Room Temperature / Frozen)
- **Y-axis:** Nail Displacement (mm)
- Draw **bars or points** for each apple condition based on your measurements.
- Use **one color for room temp, another color for frozen**.
- Compare results visually.

Graph Grid (Sketch for Students):



8. Results Analysis

Answer the following:

1. Which apple condition allowed the nail to move farther?

2. How does freezing water inside the apple affect hardness?

3. Did freezing make a measurable difference in the apple's ability to apply force?

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4. How does this relate to real-life situations (e.g., frost splitting rocks)?
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9. Scientific Explanation

- Freezing water expands inside the apple, increasing rigidity.
 - This allows the apple to exert force and move the nail into a soft surface.
 - At room temperature, the apple is too soft to do this.
-

10. Reflection Questions

1. Why couldn't the fresh apple drive the nail?

2. What does this experiment teach about how temperature affects material properties?

3. Can you think of other situations where freezing increases rigidity and causes damage?

11. Conclusion Template

This experiment shows that freezing an apple increases its rigidity, allowing it to exert force on a nail. Room temperature apples are too soft to move the nail. Freezing changes the material properties, demonstrating the effect of temperature on hardness and mechanical work.

Name: _____ Date: _____

Experiment

Write the name of your experiment in the blank space above. Then, complete the rest of this page with information about your experiment.



Question: What are you testing?

Hypothesis: What do you think will happen?



Observations: What happened during the experiment? Draw a picture or record data below.



Conclusion: What conclusions can you draw based on the results of your experiment?

Observation sheet source: WeAreTeachers, 2024