FUTURE U.

Unbreakable Ice: Composite Basics

Objective

Create a fun at-home or in-classroom project for students to learn about the science of composite materials.

Overview

In this activity, students will learn that a composite material is the combination of two or more separate materials used to create a structural unit. The combination of materials can provide more strength and even less weight than a single material. A composite structure can be broken down into two main components: the matrix and the reinforcement, and are common in many industries including the automotive and airline industry. Students will then be challenged to work together to create their own composite with ice as the matrix and the material of their choosing serving as the reinforcement. They will test the strength of their composite and compare the various designs to see which withstands breaking the most effectively.

Grade Range

3rd to 7th grade students (8–12 years old)

Timing

Active:

- Prep time—30-minutes (20-minutes learning, 10-minutes preparing the tray)
- Experiment—15-minutes

Inactive:

- Overnight freezing

Materials Needed

For this lesson, you will need:

- device to play videos or project images to the class
- aluminum baking pans or any other containers you have on hand that can hold water (2 per group of 3–4 students)
- water
- assorted materials for composite, paper towels, straws, paper streamers, straw, sawdust, shredded paper, pencils, rice, toothpicks, spaghetti, etc. (1 item per design/experiment)
- access to a freezer or method to freeze each composite model
- hammer
- safety glasses (1 per student)
- tarp or material to place composites on for testing
- Curious Composites handout (1 per student)
- Composite Design Challenge handout (1 per students group)

Preparation

Review composites using the material provided and select possible materials to use.

National Standards

- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success

Procedure

Warm Up Activity

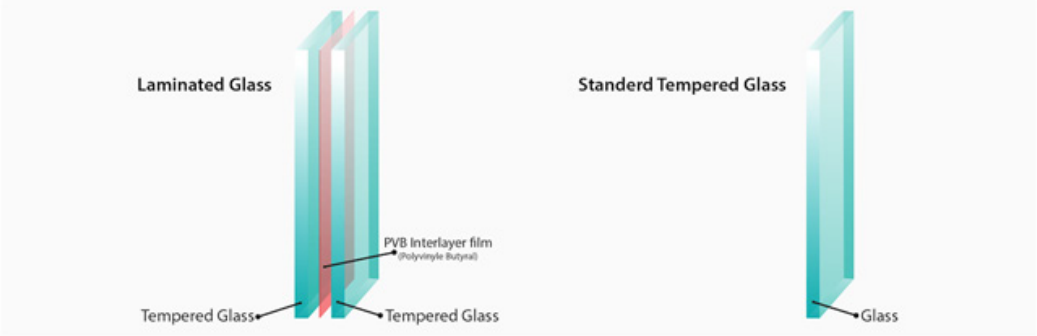
1. Begin by playing the video “Smashing Glass! Comparing Laminated vs. Tempered” for students, starting at 1:05 and pausing at 2:33. (Link: https://www.youtube.com/watch?v=cR4ZI_M5N7Q&pbjreload=101)

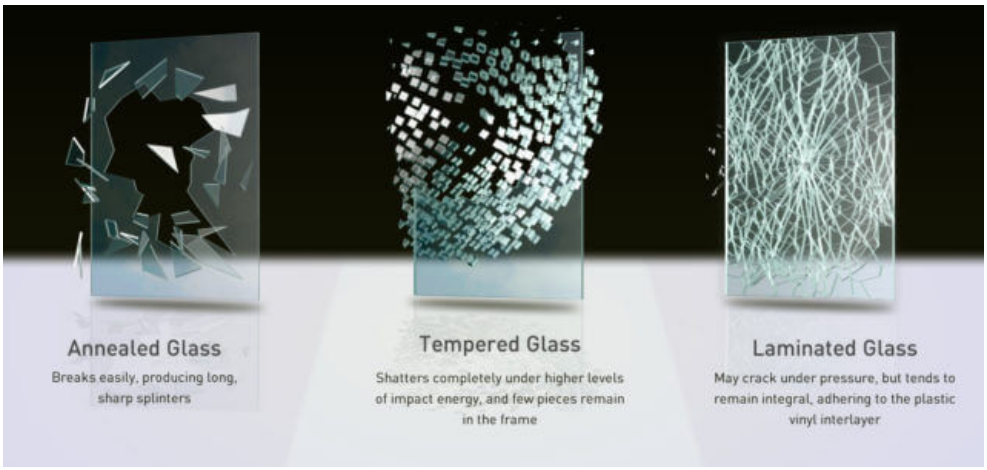
   Virtual Adaptation: for a virtual classroom, the instructor can use a videoconferencing platform to facilitate meeting with students. A screen share can be used to play all videos and project images to the group.

2. Ask students to brainstorm why the laminated glass didn’t shatter, while the tempered glass did? How could this happen when they are both glass? Allow students to share their ideas and reactions with the whole group. Record student ideas on the front board, screen, or a large piece of butcher block paper.

3. Explain to students that the laminated glass is what is called a composite. Display the following images and show students that the secret of laminated glass is in the design. The top and bottom

layer of the window are made of glass. The middle layers are made from clear plastic materials to prevent the windshield from shattering.





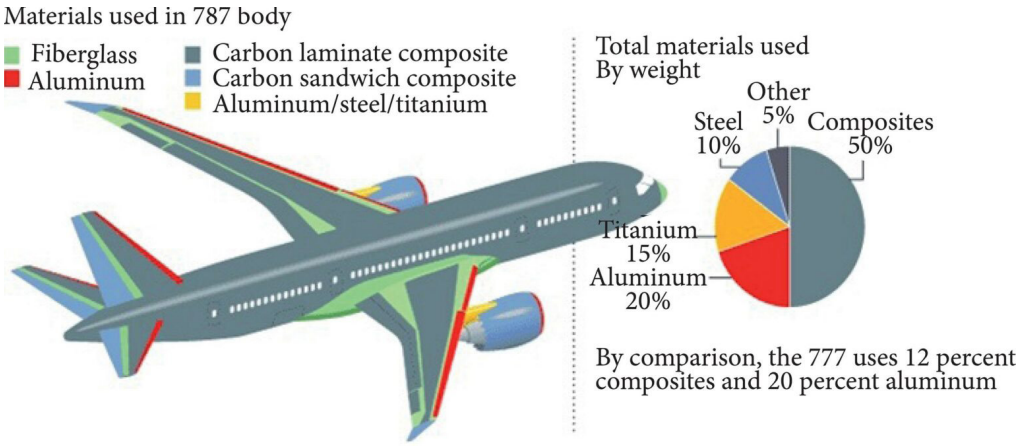
4. Give each student a copy of the Curious Composites handout and ask students to answer the questions as they view the video clip, "What is a composite?" Play the video for students. (Link: https://www.youtube.com/watch?v=8tEf_X9Rzts&pbjreload=101) Take time to pause the video as needed. Then, go over the answers as a whole class after the video concludes to ensure that all students have the information correct and completed on their student handout.

Virtual Adaptation: for a virtual classroom, students can watch the video and then be assigned to small breakout rooms using a videoconferencing platform. Students will discuss questions on the "What is a Composite" handout rather than take notes.

5. Explain to students that composite materials also have a high strength-to-weight ratio. For example, a composite beam could weigh less than a steel beam but have the same strength. Parts that use composite material are designed specifically for environmental exposure. Composites can be shaped into their needed form whereas some metal parts can be difficult to shape. Composite material use has become more feasible over time.

6. Next, share with students that some of the most exciting new developments in composites can be found in aircraft. Ask students to share what they think would be important features in designing a sturdy, safe, and flightworthy aircraft. Allow students to share their ideas.

7. Play the following video clip for students that introduces them to the use of composites in the Boeing 787 Dreamliner. (Link: https://www.youtube.com/watch?v=QefahsmfH8Q)



8. Display the following image for students:

As students study the image, explain that the Boeing 787 Dreamliner is approximately 215,000 pounds lighter than the Boeing 777, a model that uses only 12% composite material. This equals approximately a savings of 1100 kg/hour of fuel consumption which helps airlines and their passengers reduce their carbon footprint.

9. Next, ask the class to brainstorm: What design and types of materials might make the best composite? Tell them that they are about the form teams and participate in the Composite Design Challenge!

Design Team Challenge

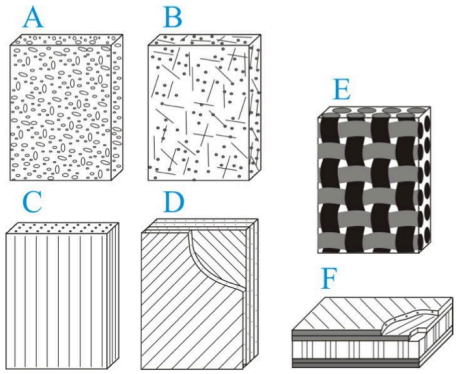
Virtual Adaptation: for a virtual classroom, students can be assigned to small breakout rooms on a videoconferencing platform to brainstorm and design their composite. One student in each group could be responsible for creation of the composite model using materials available at their home, OR each student could create their own composite model using materials from home.

10. Prepare the class for the challenge:

- Divide students into teams of three or four.
- Distribute a Composite Design Challenge handout to each group.
- Review the handout's Challenge Overview section.
- Explain that, for this challenge, they will be using water (to be frozen) as the matrix and they can choose various materials to serve as the reinforcement for their composite.
- Distribute two aluminum baking pans to each group, then review the materials that groups will have available as they build their prototype. Remind the students that minimizing resources used to build their prototype will reduce materials costs and increase efficiency in production.
- Lastly, remind students that they will be freezing their composite overnight and then they will test the strength of their composite by hitting it with a hammer!

11. Display the following image on the overhead projector as students begin to brainstorm their designs. Tell students that these may be some possible ideas for how to construct their composite.

A. composites reinforced by particles;
B. composites reinforced by chopped strands;
C. unidirectional composites;
D. laminates;
E. fabric reinforced plastics;
F. honeycomb composite structure;



12. Allow student groups 10 minutes to complete their design and construction of their composite. Rotate around the classroom as students work, and provide timing updates when there are five minutes of work time remaining.

13. All composite models should be placed into a freezer overnight.

14. The next day, assemble the class back together to begin the trials. Bring the students' attention to Step 4 on their handout. Explain that as each group shares and tests their design, the rest of the class should jot notes on its effective and ineffective design elements. They will later use these notes to optimize their design ideas.

15. Then call up groups to the front one at a time and guide them through the following process as they present and test their designs for the class. Students must wear safety glasses when testing their materials.

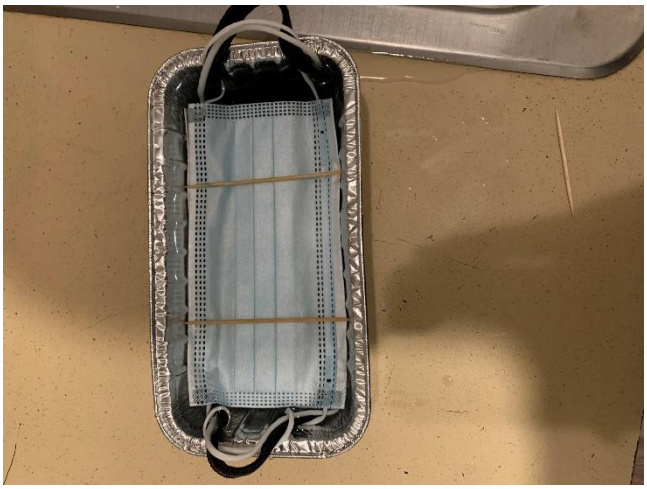
- Encourage groups to briefly share their design decisions, why did they think this would make the best/strongest composite? Why did they choose the materials they did?
- Instruct them to take their solid piece of ice and their composite out of the aluminum baking pans and place it on the floor covered by a plastic table cloth or tarp.
- Give student groups a hammer and on your cue, they should hit the composite with a hammer or drop it on the floor.
- Ask the group to determine how much damage has been done to their composite on a scale of 1–10 (1 being complete destruction and 10 being no damage) and have them share their results. (These results should be verified by the instructor.)

Virtual Adaptation: for a virtual classroom, students can show the results of their test (breaking their composite) via a videoconferencing meeting if they have made models at home.

Instruction Note: The ideal outcome would be that the ice block without composite material will shatter. The ice that includes composite material won't shatter and will be stronger. Different composite material will have ranges of durability and strength.

If doing multiple experiments using different material, compare the outcome of each break attempt and the material used.

Experiment Examples:



Wrap Up

16. Once the trials are complete, conclude the session with a full-class discussion around the students' learnings.

Discussion questions may include:

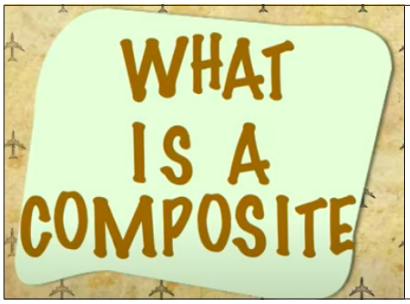
- If we were to learn from all of our design successes, what elements could we combine to create an optimized composite?
- What were some of the materials that were least successful in these designs?
- What possible products could these types of composite designs be used in?

Virtual Adaptation: for a virtual classroom, the instructor can instruct students to go to Padlet (www.padlet.com) which is a virtual bulletin board for students to add their responses to the above questions.

Before you leave, thank students for their participation and encourage them to continue learning more about advances in engineering.

Curious Composites

Video—"What is a Composite?"

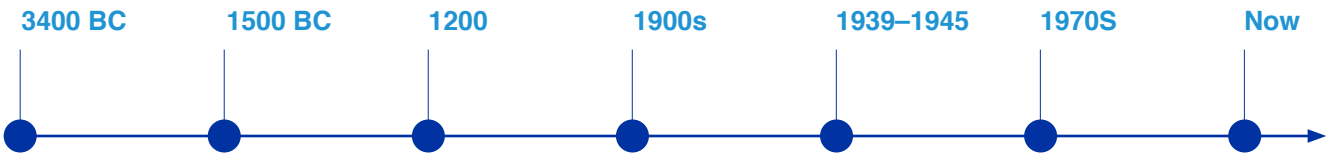


Describe the following parts of a composite:

MATRIX	REINFORCEMENT

Composite Timeline

Add information about composites for each year on the timeline!



Summary: What are some of the advantages of using composites in products?

Composite Design Challenge!

Challenge

Use frozen water as a matrix and various materials as reinforcement to create the strongest composite.

Brainstorm

What materials will you choose to use for your composite and how will you place these materials in the water? Sketch this in the space below.

Create and Experiment

1. Fill an aluminum baking pan with only water.
2. Fill an aluminum baking pan with water and chosen material in the design of your choice.
3. Place both aluminum baking pans in the freezer until both pans of water are frozen solid.
4. Once frozen, remove the ice block from the aluminum baking pan.
5. Put on safety glasses and use a hammer to break the control block of only water and your composite block.
6. Compare the strength of the two ice blocks.

Which ice block was stronger? Why do you think one was stronger than the other?

Which designs in the class seemed to be the most effective composites? Describe them.

How could/would you improve your design if you were to do this challenge again?

Composite Design Challenge!

Observe

Group	Composite Material	**Ranking 1–10** (1 being complete destruction and 10 being no damage)