Drexel-SDP GK-12 ACTIVITY

Ice Breakers

Subject Area(s) Algebra, Measurement, Problem Solving, Physical Science, Science and Technology

Associated Lesson Send in Reinforcements!

Activity Title Ice Breakers

Grade Level 7 (6-8)

Time Required 35 mins

Group Size 3-4

Expendable Cost per Group US $1

Preparatory materials: Rubbermaid® or similar rectangular containers, newspaper, water, freezer storage

Summary

This activity / demonstration illustrates how two (or more) distinct materials may be combined to form a composite material that is stronger than its constituent materials. Plain ice blocks represent an isotropic material, and a heterogeneous form of ice blocks use newspaper frozen in the ice "matrix." The combination of materials produce an ice brick that withstands higher impacts, as shown in the demonstration.

Engineering Connection

Composite materials are not only man-made, but also occur in biological systems. The xyla of plants and structures of biological tissues are typically considered composite materials. The reasons for these biological occurrences, however, parallel those of man-made structures: the combination of materials results in increased strength or function than those found in the constituent materials alone.

Keywords

composite, toughness, impact, energy, isotropic, orthotropic, homogeneous, heterogeneous

Educational Standards

- PA Science:
  - 3.1.7 – Unifying themes
  - 3.2.7.B – Apply process knowledge to make and interpret observations
- PA Math:
  - 2.3.8.A – Develop formulas and procedures for determining measurements
  - 2.4.5.B – Use models, number facts, properties, and relationships to check and verify predictions and explain reasoning
  - 2.5.8.B – Verify and interpret results using precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams
  - 2.5.8.C – Justify strategies and defend approaches used and conclusions reached
  - 2.6.5.A – Organize and display data
  - 2.7.8.D – Compare and contrast results from observations and mathematical models
  - 2.8.8.B – Discover, describe, and generalize patterns, including linear, exponential, and simple quadratic relationships

Learning Objectives

After this activity, students should be able to:

- Identify composite materials
- Hypothesize why composite materials are used in specific instances or applications
- Experimentally assess the strength of two similar objects

Materials List

Each group needs:

- 1 prepared, frozen ice block
- 1 prepared, frozen ice-newspaper block
- 1 three-point-bending jig
- 1 mass weight set (or differing weights of bagged, rubber-banded coins or coin rolls) 100-, 200, 500 gram and 1 kg masses
- 1 meter stick
- 1 piece of scratch paper for recording observations and calculations
- 1 calculator

Introduction / Motivation

Many different forms of composites can be found in biological systems and different fields of engineering. Hopefully at the end of this activity you will be more aware of them and may relate a material's structure to its function.

How many materials are used in the construction of a parking garage? You know, the ones with different levels? *(Besides concrete, rebar, or metal used for reinforcing concrete, is used).* Ok, if you didn't think of rebar (or something like it), you might notice it the next time you pass a construction site where they are preparing to pour concrete. Concrete is only strong if it is in compression, meaning that something presses against it. Concrete is very weak if it is stretched (evidenced by potholes in roads, which is caused by water that freezes and expands in porous areas or joints between concrete blocks). While we are on **Civil Engineering** topics, modern road construction mixes rubber (recycled tires) and glass (recycled glass) for a more durable and reflective road surface than concrete or macadam alone.

Plants and trees are also composed of layers of cells – xylum – that form a composite material. The hollow structure of the xylum not only provides structure for plants, but serves as a conduit for water and nutrients to other parts of the plant. Likewise, our bodies, along with those of other animals, are composed of tissues that contain multiple types of cells. Our blood vessels – arteries and veins – serve as a conduit for blood from the heart to our extremities. However, the pressures of the arterial and venous systems are markedly different, and so is the structure of arterial and venous tissues. Even among themselves, arteries may be very thick due to the presence of collagen that supports high pressure loads (found near the heart), or thin and muscular to help pump blood (found away from the heart).

New applications for composite materials are emerging in the medical fields (prosthetics, wound healing) and additional discoveries are being made on smaller length scales (micro-, nano-) to keep pace with developing and fabricating the emerging technology.

Vocabulary / Definitions

Word	Definition
Isotropic	Having material symmetry in all directional planes
Orthotropic	Differing planes of symmetry – at right angles to each other
Homogeneous	Description of material microstructure having one distinct composition
Heterogeneous	Description of material microstructure having more than one distinct composition or phase
Composite	Description of bulk (macro-scale) material if it is made of more than one type of material and all components of bulk material are subjected to any forces applied to it.
Toughness	Degree to which a material absorbs mechanical energy
Matrix	In a composite material, the constituent phase that binds with another [phase].

Procedure

Background

We're going to take a basic look at composite materials using two types of ice blocks – one is made just from water, and the ice-newspaper block is made by soaking the newspaper in water before the block is frozen.

We can conduct a simple test to show that the blocks are different. The **toughness** of a material is gauged by the amount of energy that it can absorb. In this case, we want the block to absorb energy that results from the impact of our weighted masses (or coins). If we rest the block on a platform that supports either side, we can transfer energy to the ice block by dropping [a set] weight from a [measured] distance above the ice block. Drawing on the Physics principle of Conservation of Energy, we may suppose that the energy transferred to the block, E, can be represented by the product of (i) the weight's mass, m, (ii) a gravitational acceleration constant, g, and (iii) the height at which the weight is dropped, h:

$$E = mgh\ .$$

If we keep track of the mass m and distance h used to impact the ice block until it breaks (fractures), then we may compare the resulting impact energy E that the ice block can withstand.

Before the Activity

- Read Mythbusters article "Can You Build Ships Out of Ice?" with class to preface activity.
- Display slide on board to illustrate relation of variables to procedure.
- Demonstrate the procedure (measure, measure, measure!) with a sample run.
- Provide sample data table (1 x 3) for calculating *E*nergy from *m*ass and *h*eight

With the Students

1. If using activity as a demonstration, invite several students to the front of the class to serve as a model group taking data, calculate *E* from data table on board
2. Observe students and help with difficulties encountered

Attachments

1. Worksheets appended to this document

Safety Issues

- Students should be careful when working together to make sure dropped weights do not smash hands

Troubleshooting Tips

- If ice block slides off supports, attach strips of sandpaper to supports
- Try to impact center of block with a defined edge of the weight

Investigating Questions

1. Which ice block was tougher? What can you determine from your experimental impact tests?
2. Lightweight composite materials used in aircraft construction gain their strength from stiff fibers embedded in a polymer matrix. How is newspaper-ice similar to materials used in aircraft?
3. What have you learned from this activity?

Assessment

Pre-Activity Assessment

The first page of the appended worksheet (page 6 of this document) includes a KWL chart and questions to accompany *Mythbusters* video clip.

Activity Embedded Assessment

The second page of the appended worksheet (page 7 of this document) includes data tables and reflection questions.

Additional Multimedia Support

Activity_IceBreakers.zip contains two files to support this activity:

Mythbusters_Ice_Ships.pdf, Popular Mechanics article on frozen paper boats (made out of the same ice composite), originally downloaded from http://www.popularmechanics.com/science/mythbusters/projects/4313387

Mythbusters - Frozen paper boat [HQ VIDEO].mp4, originally downloaded from http://www.youtube.com/watch?v=uQO4FDuW3PI

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Ice Breakers

- List what you know (K) and what you want to learn (W) from the blocks on your desk.

K	**W**	**L**

1. How does Jamie Hyneman compare pykrete made of newsprint to plywood?

 ____
 ____
 ____

2. In lab tests, the strength of 2-inch-thick newsprint compares with 2-inch-thick ________________.

3. To test the idea pykrete skiff idea, the Mythbusters team:

    i. traveled to _______________,

    ii. recruited high school students to unfold and soak __________-plus pounds of newspaper,

    iii. build a boat of wet newspaper laying sheets starting at the _____________ and moving _____________, which is like the ___________ on a house.

4. Did the Mythbusters prove that an operable skiff could be constructed from frozen newspaper? Why didn't the Mythbusters choose to try this in the Chesapeake?

 ____
 ____
 ____

Experiment!

1. Test the Ice blocks to see how much energy is absorbed. $E = m \cdot h \cdot 9.81$ m/s^2

Pure Ice

m	*H*	***E***

Newspaper-Ice

m	*h*	***E***

2. What was the outcome of the experiment? Which block absorbed more energy?

____

____

____

3. Why do you suppose one block absorbed more energy than the other?

____

____

____

4. What could compromise (lessen) the strength of the blocks?

____

____