Heat Transfer by Designing an Insulated Container: Grades 6 to 8

YOUR MISSION

In this activity, you will explore how different designs and insulation materials can cause an ice cube to melt at a slower rate, which will explain the effects of heat transfer. You are going to create and design an insulated box to reduce the rate of heat transfer and keep the ice cube from melting for as long as possible.

Different types of engineers consider heat transfer in many projects. The effects of heat transfer can be seen in many real-life applications, such as the coolers you take on a picnic, the insulation in your home, and more, which we will discuss further below.

Click here to watch a short video that further introduces the ice cube challenge and how it relates to engineering.

WHAT'S GOING ON

Engineers are problem solvers and they come up with solutions to problems to better the lives of everyone around them. They do this by coming up with designs, products, technologies, innovations, procedures and systems to make the world a better place.

Mechanical and chemical engineers need to consider, and also calculate, the rate of heat transfer to keep things hot or cool when their designs, projects and ideas are exposed to different temperatures. For example, a mechanical engineer may need to design a fridge that stays insulated well enough so that the fridge is not running all the time, or they will add fans and heat sinks into electrical components to keep them cool enough to run efficiently. They can also work with computers so they don't overheat - once a computer gets too hot from running too long, it can begin to slow down or experience other problems. However, with proper heat transfer the computer will not get too hot and all components will run as normal.

A chemical engineer will need to calculate the heat released or absorbed by a chemical reaction. They may need to know how much heat a nuclear power plant will generate and they can then calculate how much water is required to keep the generator cool enough to avoid any problems. In fact, the white smoke coming from the top of a nuclear power plant is not toxic smoke like most people believe, it is just steam from water that was used to keep the nuclear generators cool enough to run.

You can use the different heat transfer rates to your advantage in engineering to increase or decrease the rate of heat transfer. You likely take advantage of this on a hot summer day without even realizing it. When you are at the beach or next to a pool the sand and concrete is usually very hot from sitting out in the sun all day, but if you put a towel between you and the ground it won't feel as hot as the heat from the ground cannot transfer to your body as well as it could without the towel. In this case you are using the towel as an **insulator**. You also experience heat transfer when you jump in a pool when the temperature outside is high. When our bodies are very warm and then we jump into cold water, the heat is transferred from our body to the water, cooling us down. Heat can transfer much more quickly in water than in air.

The three types of heat transfer are **conduction, convection** and **radiation**. In this activity the heat from the air is transferred to the ice cube, causing it to melt. Before we get to explaining how you to start your insulated heat transfer box, let's go through a few key terms you should know before you get started!

KEY TERMS

- **Heat Transfer:** The movement of thermal energy from one item to another item of a different temperature. Heat always moves from a warmer object to a cooler object.
- **Conduction:** The transfer of heat energy from one thing to another by direct contact.
- **Convection:** The transfer of heat energy between a surface and a liquid or gas that is in motion.
- **Radiation:** The transfer of heat energy without the need for another object or medium, such as when the energy of the sun travels through space to warm the earth's surface.
- **Insulation/insulator:** A material that reduces heat transfer. We use installation in the walls of our homes to keep it at a comfortable temperature.
- **Heat:** Heat is a form of energy in an object. Adding heat causes an object to increase in temperature and becomes hotter.

MATERIALS NEEDED

- a cardboard box
- masking tape
- paper
- aluminum foil
- rubber bands
- wax paper
- newspaper
- paper
- any other material you have on hand that you think will be a good insulator
- 2 ice cubes

WHAT YOU NEED TO DO

- You will need 2 ice cubes for each design. Make sure you have at least 2 ice cubes ready to go.

- Collect all other materials shown above. Ask a parent or teacher if you need help finding some good materials to use for insulation. If possible, old towels, shirts, etc. can also be used, along with any of the materials listed above, or your own ideas. Be sure to ask your parent or teacher before using any materials.

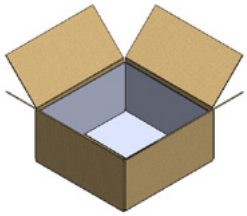
- Grab your pen and paper and sketch out your design. Remember, you want to figure out a way to keep the ice cube from melting for as long as possible. You want to create an insulating environment within the box to keep heat from the ice cube. You can create multiple designs, using different insulation materials.

- Predict what insulation materials will cause the ice cube to melt the slowest. Record your predictions.

- Predict what your ice cube within this system will look like after 90 minutes. Record your predictions.

- Build your system to keep the ice cube from melting.

- Place one ice cube in the box and another ice cube in a bowl beside the box. The ice cube beside the box is the "control" for the experiment. This gives us something to compare the effectiveness of our design to.



- Take pictures of the ice cubes to remember what they looked like at the start of the experiment.
- Leave the two ice cubes for a specified amount of time – it can be anywhere from 45 to 90 minutes, depending on how much time you have.
- After the time is up go back to the ice cubes and compare how your ice cube inside the box looks to how the ice cube in the open bowl looks.

  a. Is your ice cube completely melted or only slightly melted?

  b. Is the control ice cube completely melted?

  c. Was your prediction for how the ice cube would look correct?

- Leave the ice cube for a while longer to see how long it takes for the ice to completely melt within your box.
- Try to think of ways to improve your box and allow the ice to melt at a slower rate. Repeat the experiment with different designs, using different materials.
- See if your prediction of the best insulating material for the ice cube is correct.

FURTHER REFLECTIONS

1. What happens if you direct a fan towards the experiment, blowing air onto the two ice cubes?

2. What happens if you completely seal the box with the ice cube inside compared to leaving the top of it open?

3. Will adding more of the insulating material help the ice cube to melt slower?

4. Does the size of the box change how quickly the ice melts?

5. What materials might work better in this experiment.

ENGINEERING DESIGN PROCESS

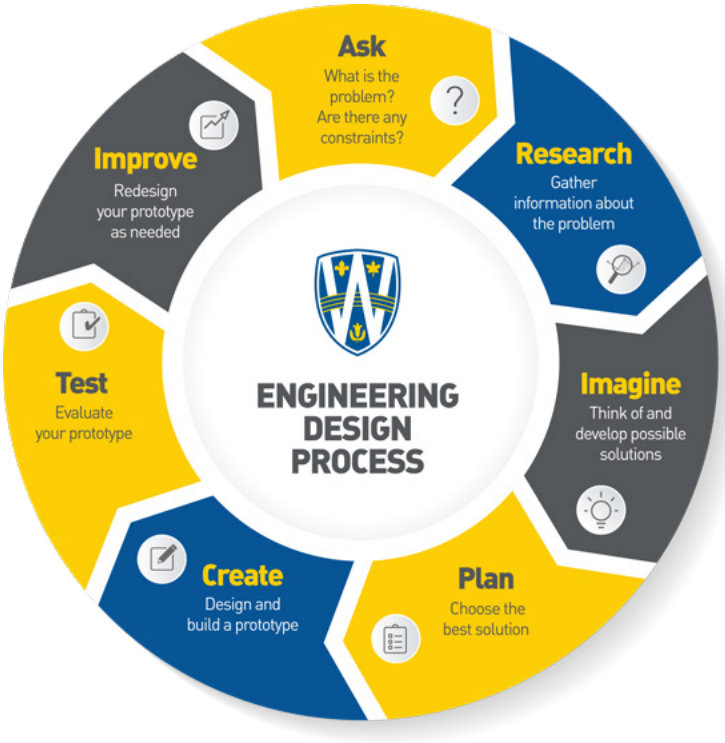
All engineers use the Engineering Design Process to plan, build, test and reflect on their designs and when coming up with solutions to a problem. The steps for the Engineering Design Process are listed below. Use the Engineering Design Process to test and improve your design.

First, think of the problem.

How can you fix it? Think of as many ideas as you can that you think will solve this problem.

It might be helpful to first sketch out your ideas on a piece of paper. Make as many different designs as you can!

Test and compare all of your solutions. Which one solves the problem and works the best?



CURRICULUM UNIT CONNECTIONS

Grades 6 to 8 – Understanding Earth and Space Systems – Heat In The Environment; Understanding Structures and Mechanisms – Systems In Action

SHARE YOUR DESIGNS WITH US!

Tag us on our UWindsor Engineering Social Media Pages and show us your designs!

Twitter: @UWindsorENG
Facebook: @UWindsorEngineering
Hashtag: #UWindsorENG

REFERENCES

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Strickland, V. [Victoria Strickland]. (2020, March 31). Ice Cube Challenge. [Video] https://www.youtube.com/watch?v=98YB5F0lAeU