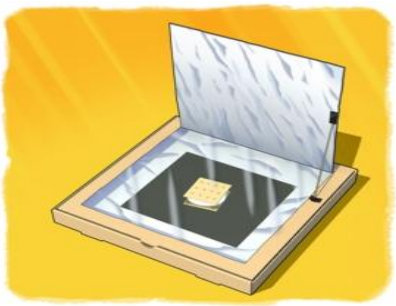
greenlight for girls
The future is full of possibilities



G4g's Engineering a Solar-Powered Oven Experiment

Overview

Using an ecologically friendly technology, we will be demonstrating the concepts behind solar energy. As energy is not something that is tangible, it can be a tricky concept to teach. With this hands-on experiment, we will engage the student on a concrete level and they will get to experience what it's like to engineer something… all the while activating their senses. They will be able to directly see how energy from the sun's rays can transferred to a form of heat for cooking; they will also feel their solar oven getting warmer; and best of all they'll get to taste the rewards of their own creation directly- by cooking up a tasty treat!

Learning Objectives

In the g4g engineering a Solar-Powered Oven experiment, through hands-on practice and discussion, the students will be able to:

Scientific

- Observe how **solar energy** is used to heat up your solar oven; recognize that your design is made to absorb more heat from the sun than it releases out in the atmosphere; & learn concepts such as:
  a. Designing a system that allows the suns' rays to be **reflected** into your solar oven
  b. Designing a **greenhouse** roof, which allows direct and reflected sunlight to pass through, trapping the heat as **radiated energy**
  c. Designing a **heat sink** which absorbs all the sunlight coming in, warms up, and then radiates (or distributes) this trapped heat (radiant energy)

Intrinsic

- Recognize that science (STEM) is everywhere around us & an important part of everyday life.

Thought-provoking

- Propose professions that focus on energy-efficiency and reducing "carbon footprints" in homes and commercial buildings, such as your local Solar Energy Systems Engineer; or a Commercial/Industrial Designers whose focus is to design every type of manufactured good- from toys to toasters- that are as beautiful and pleasing to look at as they are functional!

***These objectives will be measured by asking questions throughout and at the end of the workshop session that identify if these objectives have been learned

Materials needed

Here's what you need…

- Pizza Box (the larger the better)
- Box knife or scissors
- Ruler & Marker/Pen
- Wooden skewer, stick, or spoon
- Aluminum foil
- One sheet of black construction paper
- Plastic wrap
- Shipping tape or black electrical tape
- White school glue or clear tape
- A warm, sunny day
- Cooking delicious "s'mores": Graham (or gingerbread) crackers, your favorite chocolate bars and marshmallows
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How to conduct the experiment

Introduction

In this experiment, not only will the students get to learn what harvesting solar energy is all about, but they will gain insight into the life of an engineer by learning to create something both practical and functional. Finally, the students will be able to stimulate their creative thought process on how to improve their design. For example, could they make it more attractive to the eye, which is many times just as important as making a functional and efficient solar-powered oven!

Science Topics: Heat, energy, the sun, solar energy, greenhouse, reflected light, heat sink, radiant energy and insulation
Skills: Observing, questioning, inferring, hypothesizing, creating, experimenting, team building
Benchmarks: listening to directions and working together as a team

Lab Objectives

- Following instructions on how to use everyday household supplies to get creative and build a functional solar-powered oven
- Encourage the students to retry the experiment at home to learn and improve their original design by looking for ways to build a second, more efficient one
- Have students discuss what worked well and what didn't

Procedure

**** For safety reasons and to save some time, Step #2 could be done before you begin the experiment with the girls!**

1. Introduce the concept – Becoming an energy-conscious engineer!
2. **Ask students to begin by taking the ruler and drawing a square (leaving a one-inch border) on the top part of the pizza box lid. With adult supervision, use a utility knife or scissors to carefully cut along three lines, leaving the backside of the square intact to create a flap!
3. Forming groups of two, three or four to demonstrate teamwork, ask the students to write their names at the edge of the pizza box! - Fold the cardboard along the uncut line of the square to form "the flap".

4. Next, we must line the "inner" side of flap with aluminum foil, with the shiny side up! While trying to keep the foil wrinkle-free, fold the edges of the foil around the "outer" side of the flap and use glue or tape to hold it tightly in place.

5. Cover the opening made by the flap with plastic wrap, attaching the plastic to the edges of the box using shipping tape or black electrical tape, making sure there are no holes and all the edges are completely attached to the lid.
6. Now, we must also line the inside of the box with pre-cut aluminum foil (shiny side up)! The idea is when you shut the box, the entire interior would be covered with foil, so it would be best to line the bottom of the pizza box, as well as the inside edges of the lid.
7. Glue or tape a sheet of black construction paper to the bottom of the box, which will act as your solar oven's heat sink!
8. Lastly, use a wooden skewer, stick, or spoon to prop the solar oven's lid up (at about a 90 degree angle)
9. Leave the solar oven outside on a hot day (best times between 11am and 3pm) to cook your food and you can optionally preheat your oven by setting it in direct sunlight for up to one hour.
10. Making S'mores: Break your graham or gingerbread cracker in half and place a piece of chocolate on one half and one marshmallow on the other half of the cracker. Place the "half" s'mores inside your solar oven on top of the black paper. Place the oven in direct sunlight for at least 30 minutes; turning it to make sure the inner flap faces the sun. When the marshmallow is soft, your s'mores are ready to be eaten, so sandwich them together and enjoy!

Assessment

Within the concepts:

1. What is solar energy?
2. What is the purpose of a greenhouse?
3. What is reflected light and why is it important to heat up your oven?
4. What is the purpose of a heat sink and radiant energy?

Within the procedures:

1. What do you think the purpose of the foil-covered flap is (step 4)?
2. Why do you think it's important to make sure the opening is completely sealed by the plastic wrap (step 5)?
3. Why do you think we should line the inside of the box with foil as well (step 6)?

4. Why do we use BLACK construction paper? How do you think this will help cook your food (step 7)?
5. Do you feel your oven getting warmer (step 9)?
6. How long did it take to cook your s'mores in your solar oven (step 10)?

To conclude…

1. How could you have improved the engineering of your first design? Is there something you could have done better?
2. How can we now make a second, more efficient design? Can you think of ways we could insulate our oven more efficiently (i.e. keeping the heat in)?
3. Do you think our solar-powered oven would still work on a cloudy day?

<u>The science behind-the-scenes</u>

Here we are designing a system where the heat from the sun can be trapped inside your pizza box solar oven. There are many devices that have been developed which trap this solar energy, which is simply light and heat emitted from the sun. One example is the solar photovoltaic (PV) panels used to heat up your home! Solar ovens exist as well, and are not only used to cook food, but they can also pasteurize water to make it drinkable, or even sterilize instruments!

So how does a solar oven work? It is essentially a "collector", collecting the sun's rays by designing it in a way where it absorbs more heat than it releases.

To understand how this happens, we begin with how to use the full potential of the sun. The sun's rays come in to earth at an angle, so when we created the aluminum foil-covered flap and also lined the inside edges, we allowed the rays to be reflected into our oven. The plastic wrap "window" we created functions as a greenhouse roof, allowing direct and reflected sunlight to pass into the inner box, essentially trapping it there. At the bottom of the inner box, where we placed a sheet of foil covered with black construction paper, we designed our heat sink, which absorbs the direct and reflected sunlight and then radiates this heat; and it is this radiant energy that stays mostly trapped in the inner box that warms up the oven! We use black paper simply because it is the color that absorbs the most heat. The plastic window holds heat in, but it is also very important to provide some sort of insulation & provide barriers for the air pockets so that less heat sneaks away and your oven becomes more efficient.

This is great to try out during BBQs and especially while camping! On a sunny day, your oven will reach about 71-93 degrees Celsius, and although this means it may take twice the time to cook your food, the benefits are that it is very easy and safe to use, you can leave it alone while it cooks your food, and of course most importantly, you are choosing to be an energy-conscious individual! And don't worry about burning the paper, as paper burns at 111 degrees Celsius, and your solar oven should not get that hot!

But what about cooking on a cloudy day? Depending on how thick and dense the clouds are and how hot of a day it is, you will still have the sun's rays passing through, and you will still be able to heat up your oven, but it will just take a longer period of time.

Try this...

For your second design, try providing your solar-powered oven with better insulation! You can use newspapers, for example, by rolling them up, sheet by sheet and placing them on the bottom of the box. The idea is to form a border around the cooking area where the box can still close, but where you have also created a seal inside the box so that air, and therefore heat, cannot escape.

Try this…
Why not also try out boiling water in a pot or pan? In order to do this, however, you should think about why a pizza box would probably not be very functional anymore and why you would need to engineer a more efficient solar-powered oven for this purpose. Read more on engineering a different kind of solar-oven here: http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p018.shtml#procedure

PLUS Tips on the Engineering Design Process: http://www.sciencebuddies.org/engineering-design-process/engineering-design-process-steps.shtml#theengineeringdesignprocess

Try this…
Why not make it a science fair project? You can test many variables here… try with and without a the foil-covered lid serving as a reflector… think of different types of heat-absorbing materials for your heat sink… research different types of insulation you can provide… OR **go for the challenge!** Engineer a few different solar ovens and see which one is most efficient at heating up a given volume of water, for example.
**Remember that for each experiment, it is important to change only ONE variable and keep the others constant. Most importantly, have fun with it!

Our Sources

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