“Catching Some Rays”

Greater Essex County District School Board

grade 7 science

ecoschools project
## Grade 7 Science “Catching Some Rays”

### Overall Expectations

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7S53</td>
<td>Identify, through experimentation, ways in which heat changes substances, and describe how heat is transferred.</td>
</tr>
<tr>
<td>7S54</td>
<td>Explain how the characteristics and properties of heat can be used, and identify the effect of some of these applications on products, systems, and living things in the natural and human-made environments.</td>
</tr>
</tbody>
</table>

### Specific Expectations

<table>
<thead>
<tr>
<th>Code</th>
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</tr>
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<tbody>
<tr>
<td>7S55</td>
<td>Distinguish between the concept of temperature and the concept of heat (e.g., temperature is a measure of the average kinetic energy of the molecules in a substance; heat is thermal energy that is transferred from one substance to another).</td>
</tr>
<tr>
<td>7S56</td>
<td>Compare the motions of particles in a solid, a liquid, and a gas using the particle theory.</td>
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<tr>
<td>7S57</td>
<td>Explain how heat is transmitted by conduction, convection, and radiation in solids, liquids, and gases (e.g., conduction: a pot heating on a stove; convection: a liquid heating in the pot; radiation: the air being warmed by heat from the element).</td>
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<tr>
<td>7S58</td>
<td>Describe how various surfaces absorb radiant heat.</td>
</tr>
<tr>
<td>7S62</td>
<td>Compare, in qualitative terms, the heat capacities of common materials (e.g., water and aluminum have greater heat capacities than sand and Pyrex).</td>
</tr>
<tr>
<td>7S65</td>
<td>Formulate questions about and identify needs and problems related to heat (e.g., interactions involving energy transfers), and explore possible answers and solutions (e.g., identify the steps that could be followed to test the effectiveness of the heating system in a home that uses solar energy).</td>
</tr>
<tr>
<td>7S66</td>
<td>Plan investigations for some of these answers and solutions, identifying variables that need to be held constant to ensure a fair test and identifying criteria for assessing solutions.</td>
</tr>
<tr>
<td>7S67</td>
<td>Use appropriate vocabulary, including correct science and technology terminology, to communicate ideas, procedures, and results (e.g., state the boiling and freezing points of water, room temperature, and body temperature in degrees Celsius; correctly use the terms heat conductor and heat insulator).</td>
</tr>
<tr>
<td>7S68</td>
<td>Compile qualitative and quantitative data gathered through investigation in order to record and present results, using diagrams, flow charts, frequency tables, bar graphs, line graphs, and stem-and-leaf plots produced by hand or with a computer (e.g., plot a graph showing the decrease in temperature of various liquids from identical initial temperatures).</td>
</tr>
<tr>
<td>7S69</td>
<td>Communicate the procedures and results of investigations for specific purposes and to specific audiences, using media works, written notes and descriptions, charts, graphs, drawings, and oral presentations (e.g., use a diagram to illustrate convection in a liquid or a gas).</td>
</tr>
<tr>
<td>7S73</td>
<td>Identify different forms of energy that can be transformed into heat energy (e.g., mechanical, chemical, nuclear, or electrical energy).</td>
</tr>
</tbody>
</table>
With current energy costs so high, it makes sense to utilize the sun's renewable energy source to meet some of our basic living needs.

**Build a Solar Oven**

Besides explaining these principles in the process of building and using the ovens, here are several other points you might want to make:

- Cooking food takes a lot of energy! By using solar energy, we can save a lot on fuel.
- Cooking takes time, and the sun will change position during that time. Therefore, somebody, such as a vigilant cook, may need to align the solar oven now and then to keep the sunlight entering. Mechanisms that track the sun and adjust the device automatically are called “heliostats” (like thermostat but with helio which means sun).
- Solar ovens have been used for a long time. In the 1830's, the British astronomer John Herschel used a solar collector box to cook food during an expedition to Africa. Nowadays, one can buy commercial solar ovens ranging from small single dish units to large units that can feed many people at once and that have to be hauled around on a trailer.
- Without the reflector flap, the solar oven becomes what is called a “flat plate collector.” Flat plate collectors are used for many applications, such as heating water (the reason for not using a reflector is that it is not really needed for these applications, and thus alignment difficulties associated with reflectors can be avoided). One of the first known uses of solar hot boxes was by the cooks of the Roman Emperor Tiberius who wanted to eat cucumbers all year round. The cooks satisfied his regal appetite by using a solar hot box, a kind of flat plate collector, to grow the cucumbers all winter long! Nowadays, many people also use flat plate collectors to heat water for their pools and houses.
The simplest solar oven design, as given below, can get up to 200 degrees Fahrenheit on a warm, sunny day, enough, for example, to make smores (graham cracker sandwiches of chocolate chips and marshmallows). Several optional features will enable the oven to get even hotter, which may be desirable in cooler weather, or for more serious cooking. One should allow ample time for cooking (roughly twice as long as it would take in a conventional oven, and for smores, it works best to leave the sandwiches open while cooking so that direct sunlight falls on the marshmallows and chocolate chips). We do not recommend trying to use the oven outside in temperatures below about 15.56 degrees Celsius. If its cool outside, try a sunny windowsill.

Note: Many pizza shop owners will be more than willing to donate boxes. In return, you may want to ask a local reporter to cover the event. Ask the reporter to specifically mention the pizza shop’s donation in any news article that appears.

Extension Challenge: Build a Solar Water Heater

Using the information and data obtained from Building a Solar Oven, the challenge is to build a solar water heater.

Students will discuss the concept of a passive solar water heater system and its components.

Students will study how a solar water heater functions by making a simple, passive solar model and taking temperature measurements to confirm that it works.

Students will discuss the advantages and disadvantages of renewable and non-renewable energy sources.
Major Understandings

What is Energy?

Energy is the ability to do work, the ability to make a change. Everything that happens in the world involves a change of some kind, the exchange of energy in some way. The total amount of energy in the universe remains the same. When we use energy, we do not use it up; we convert one form of energy into other forms. Usually the conversion of energy produces some heat which is considered the lowest form of energy since it dissipates into the surroundings and is difficult to capture and use again. Energy is categorized in many ways: by the forms it takes and by what it does – the changes it makes – the effects we can see or feel or measure.

What Energy Does

Energy is recognized in the following ways:

- Energy is light – energy produces light – the movement of energy in transverse electromagnetic waves – radiant energy.
- Energy is heat – energy produces heat – the movement of atoms and molecules within substances – thermal energy.
- Energy is sound – energy produces sound – the back-and-forth vibration of substances in longitudinal waves.
- Energy is motion – energy produces motion – kinetic energy.
- Energy is growth – energy is required for cells to reproduce – chemical energy stored in the bonds of nutrients.
- Energy is electricity to run technology – the movement of electrons from atom to atom.

Forms of Energy

Energy is recognized in many forms, all of which are potential or kinetic:

- Thermal Energy (heat)
- Mechanical Energy (energy in wood, fossil fuels)
- Electrical Energy (electricity, lightning)
- Nuclear Energy (fission, fusion)
- Radiant Energy (visible light, x-rays, microwaves)
- Sound (motion)
Background

Solar energy is energy from the sun. The sun is a giant ball of hydrogen and helium gas. The enormous heat and pressure in the interior of the sun cause the nuclei of two hydrogen atoms to fuse, producing one helium atom in a process called fusion. During fusion, nuclear energy is converted into thermal (heat) and radiant energy. The radiant energy is emitted from the sun in all directions and some of it reaches Earth. Radiant energy is energy that travels in electromagnetic waves or rays. Radiant energy includes visible light, x-rays, infrared rays, microwaves, gamma rays, and others. These rays have different amounts of energy depending upon their wavelength. The shorter the wavelength, the more energy they contain.

Activity #1 Build a Solar Oven

Suggested Approach

Students can work in groups. One can be the timer, and the others can read and record the temperatures. All students should participate in the construction of the solar oven.

After the students have collected and interpreted their data, discuss the importance of the conversion of light energy to heat energy.

Supplies & Tools

- thermometers (one per group)
- recycled pizza box
- black construction paper
- aluminum foil
- clear plastic (heavy plastic laminate works best)
- non-toxic glue
- tape
- scissors
- ruler
- magic marker
- wooden dowel or straw
This solar oven has been adapted from many designs. Please feel free to improvise! You may want to try making smores (graham crackers with melted marshmallow and chocolate) or English muffin pizzas.

The pizza box solar oven can reach temperatures of 275 degrees, hot enough to cook food and to kill germs in water. A general rule for cooking in a solar oven is to get the food in early and don’t worry about overcooking. Solar cookers can be used for six months of the year in northern climates and year-round in tropical locations. Except the cooking time to take about twice as long as conventional methods, and allow about one half hour to preheat.

**Procedure**

**How to Make Your Pizza Box Oven**

Draw a one inch border on all four sides of the top of the pizza box. Cut along three sides leaving the line along the back of the box uncut. See Diagram #1.

Form a flap by gently folding back along the uncut line to form a crease. Diagram #2. Cut a piece of aluminum foil to fit on the inside of the flap. Smooth out any wrinkles and glue into place. Measure a piece of plastic to fit over the opening you created by forming the flap in your pizza box. The plastic should be cut larger than the opening so that it can be taped to the underside of the box top. Be sure the plastic becomes a tightly sealed window so that the air cannot escape from the oven interior.

Cut another piece of aluminum foil to line the bottom of the pizza box and carefully glue into place. Cover the aluminum foil with a piece of black construction paper and tape into place. See Diagram #3.
Close the pizza box top (window), and prop open the flap of the box with a wooden dowel, straw or other device and face towards the sun. See Diagram #4. Adjust until the aluminum reflects the maximum sunlight through the window into the oven interior.

Your oven is ready! You can’t try heating smores, English muffin pizzas or hot dogs, or even try baking cookies or biscuits. Test how hot your oven can get using a simple oven thermometer!

**Construction Questions to Discuss**

1. What is the function of the transparency top? (The transparency lets the sunlight in, but doesn’t let the heat out.)

2. What is the importance of the insulation? Where are the best places for insulation? (The insulation keeps the heat in the cooker.)

3. What is the function of the flap in the lid? (The lid is used as a reflector to increase the amount of energy that goes in the box.)

**Think About This**

4. What are some other ways you can use the heat energy from the sun? (to heat water, heat homes, dry clothes, dry food, etc.)

5. What are some advantages and disadvantages of using the sun’s energy for cooking? (Advantages: low cost, no pollution, etc.. Disadvantages: takes longer, difficult to regulate temperatures, doesn’t work at night or on cloudy days, etc.)

6. When do most people eat a hot meal? How might this affect the widespread use of solar cookers? (Most people eat their hot meals in the early evening. Meals cooked in solar cookers would have to be started in the middle of the day. Many people don’t plan that far ahead, or are not home at that time to prepare the cooker.)
Social Studies Extension

Other uses for solar cookers: they are a safe source of low-temperature heat for a variety of experiments.

7. Conduct library research on food preparation in other times and other places, such as any tropical country. Was the sun used in food preparation and food storage? How? Where? When? With what success? To what disadvantage?

8. Fuel wood (biomass) is the world’s largest source of cooking fuel. What are some of the social, economic and environmental impacts of the widespread use of fuel wood for cooking?

9. Cooking over an open fire is a terrible waste of energy. Several international agencies have developed “energy efficient” ovens for cooking with wood. What do they look like, and what has prevented their widespread introduction and use?

- Demonstrate whether dyes diffuse faster in hot or cold water.
- Heat a photovoltaic cell and compare its output to that of an unheated cell.
- Sterilize ditch water, after observing microorganisms under a microscope.
- Test how well different types of insulation protect an ice cube placed in the cooker.
- Illustrate conduction by trying to warm different objects.
Solar Water Heater Challenge

Class Challenge: Using your solar ovens

Part 1

1. Obtain a 5 inch aluminum pie plate.

2. Fill your pie plate with 150 mL of water at room temperature and place inside your solar oven.

3. Place your solar oven in the most optimum location outside. Obtain an initial starting temperature of the water.

4. Check the temperature of the water every 10 minutes for 40 minutes and record your results (subtract the starting temperature so that you are recording only the increase in temperature.)

5. Graph your results on a graph of temperature vs time.

<table>
<thead>
<tr>
<th>Temperature Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
</tr>
<tr>
<td>0 minutes</td>
</tr>
<tr>
<td>10 minutes</td>
</tr>
<tr>
<td>20 minutes</td>
</tr>
<tr>
<td>30 minutes</td>
</tr>
<tr>
<td>40 minutes</td>
</tr>
<tr>
<td>Total Temperature Change</td>
</tr>
</tbody>
</table>
Part 2

Using the information and data you have collected in this lab, your challenge is to design and construct a solar water heater out of recycled materials that will heat 150 mL of water in the shortest amount of time (maximum time is 40 minutes); as well as maintain the temperature of the water for as long a period of time as possible (out of the sun for 40 minutes). Record your data for heating and cooling. **Draw a graph** (temperature vs time) to display your results.

During this challenge you may collect data as many times as you wish. Remember the total length of time you have to heat your water is 40 minutes!

Teacher’s Note: The times suggested in this lab for heating and cooling can be modified to fit your science period. You may want this to be a home challenge.

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**Challenge Reflection**

1. How could I improve on my design for this challenge?
2. Would my design work for larger quantities of water? What modifications would have to be made to my design to accommodate larger quantities of water?
3. Why is it important to look at the length of time it takes for my water to cool down? What improvements could I make to this aspect of my design?
Suggested Links for Further Energy Exploration

For additional information on renewable energy we suggest these locations:

**Just for Kids**
- Earth Dog (www.earthdog.com/renew)
- Energy Quest (www.energy.ca.gov/education)
- Kid Magnet (www.kidmagnet.com)

**Energy Products and Systems**
- Applied Power Corporation (www.appliedpower.com)
- Ascension Technology, Inc. (www.ascension-tech.com)
- 4lots (www.4lots.com)
- Solar Depot (www.solardepot.com)
- Sundance Solar (www.sundancesolar.com)

**For Home Owners/Architecture/Residential Design, etc.**
- Home Power Magazine (www.homepower.com)
- Solar Design Associates (www.solardesign.com)

**Energy Advocacy Groups**
- Alliance to Save Energy (www.ase.org)
- Green Power Development (GPD) (www.GPDnet.com)
- International Solar Energy Society (ISES) (www.ises.org)
- Massachusetts Technology Collaborative (www.mtpc.org)
- Utility Photovoltaic Group (UPVG) (www.ttcorp.com/upvg)

**Resources for Sustainable and Renewable Energy Information**
- Energy Efficiency and Renewable Energy (www.eren.doe.gov)
- Network (EREN) Energy Information Administration (EIA) (www.eia.doe.gov/fuelrenewable.html)
- Solar Cooking Archive (www.solarcooking.org)
- Solstice (CREST) (solstice.crest.org/index.shtml)
- Sustainable Missesota (www.me3.org)

**Education and Research**
- Advanced Research Development, Inc. (www.ardev.com)
- Concord Consortium (www.concord.org)
- Energy Foundation (www.tufts.edu.tepe/energy)
- Florida Solar Energy Center (www.fsec.ucf.edu)
- Interstate Renewable Energy Council (IREC) (www.irecusa.org)
- National Renewable Energy Laboratory (NREL) (www.nrel.gov)
- PBS Online (www.pbs.org/ktca/newtons)
- Sandia National Laboratories – PV Division (www.sandia.gov)
- Solar Dome (www.solardome.com)
- Solar Energy International (www.solarenergy.org)
- Sundance Solar Products, Inc. (www.SundanceSolar.com)

**National Trade Organizations**
- American Bioenergy Association (www.biomass.org)
- American Wind Energy Association (AWEA) (www.awea.org)

**Utilities**
- Massachusetts Electric Company (www.masselectric.com)

**References**
Source of lesson plan: based on activity from
2. The Solar Cooking Archive (www.solarcooking.org/plans.htm)
4. Created for the NTEP II Fermilab LInC program sponsored by Fermi national Accelerator Laboratory Education Office and Friends of Fermilab, and funded by United States Department of Energy, Illinois State Board of Education, North Central Regional Technology in Education Consortium which is operated by North Central Regional Educational Laboratory (NCREL), and the National Science Foundation. (http://www-ed.fnal.gov/ntep/f98/projects/nrel_energy_2/solarovens.html)

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