Experiments:

By changing different variables with this solar thermal kit, you can learn a lot about what makes a solar water heating system more or less efficient. You can design a number of experiments by isolating one variable at a time and examining how this variable affects the performance of your system.

Variables to explore:

- Box color
- Light intensity
    - use of reflective materials
    - time of day of experiment and/or angle of collector
    - cloud cover
- Insulation of box and storage container
- Use of the greenhouse effect
- Tube design
    - Pattern
    - Length of tubing
- Rate of water pumping
- Amount of time
- Use of capacitor to sustain water flow if solar panel stops working
- Material and color of tubing
    - Aluminum tube vs. copper tube vs. clear plastic vs. black rubber

Sample Experiments:

Experiment 1: Color of the Solar Collector

By conducting this experiment, you will be able to quantify the difference between 2 colors of a solar collector (preferably black and white). Leaving all other variables constant, you will only change the color of the box that houses the tubing. Which system will be more efficient?
If you have a second water pump, you can compare the two boxes simultaneously. These instructions will show you how to do it separately.

1. Fill two bins with water. Leave them out for an hour or two so that they will both be at room temperature.
2. Your kit came with two white cardboard boxes with clear plastic lids. Paint one of the boxes black or another dark color. Leave the other box white.
3. Start with the white box. Arrange the tubing in a simple pattern that will be easy to repeat.
4. Record your initial water temperature.
5. Set up the solar collector in a sunny place. Connect the tubing to the water pump and the wires to the solar panel. Make sure that water is pumping through the system and flowing back into the water storage container.
6. Leave the system in the sun for 20 minutes then record the final water temperature. Also record the temperature change (final temp. - initial temp.).

Now repeat the experiment using the black box. Make sure you arrange the tubing exactly the same way as you did in the white box. Try to clear all the water from the first trial out of the tubing before you begin this second trial. Remember to set up the collector in a sunny place. You should try to keep all the variables constant except for the color of the box.

Measure the initial water temperature, then let the black box system run for 20 minutes. Record the final temperature and calculate the temperature change from start to finish.

Is there a noticeable difference between the two collectors? If so, which system had a greater temperature change in the 20 minute time period? Is this result what you would have predicted? Why is this system better than the other?

If you have time, running the experiment for longer than 20 minutes will give you better results. Eventually, the temperature will stop rising. How hot does it get after an hour?

Experiment 2: Length of Tubing in the Collector

In this experiment you will examine how well the solar collector works with different lengths of tubing.

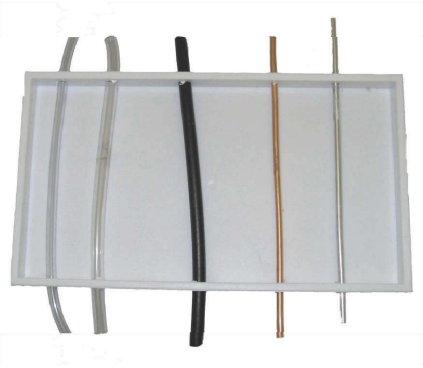
1. Set up 3 different bins of water and allow them to reach room temperature.
2. Start with the full 25 feet of clear plastic tubing. Coil it up to fit as much as possible in the plastic collector box.
3. Place the Plexiglas lid over the collector, connect the tubing to the water pump, and the solar panel wires to the water pump wires. Record the initial water temperature.
4. Place the collector in a sunny place and let the system run for 20 minutes.
5. Record the final temperature and calculate the temperature change.
6. Cut the tubing down to 15 feet and repeat the experiment.
7. Cut the tubing down to 7 feet and repeat the experiment.

Is there a noticeable difference in the efficiency of each tubing length? Which length allowed the water to heat up the most? Is this a result you would have predicted? Why did this length of tubing work the best?

Experiment 3: Different Tubing Materials

Does the type of tubing you use affect the efficiency of your solar thermal system? In this experiment, you will compare how well different tubing materials heat water. Your kit came with a few different tubes that you can compare: clear plastic, black rubber, copper, and aluminum.

1. Set up 4 different bins of water and allow them to reach room temperature.
2. Cut each of the 4 different materials to the same length. It is hard to cut the metal tubes, so we recommend leaving those and cutting the plastic tubes to match the metal ones.
3. If you have 4 water pumps, you can try all 4 tubes at the same time (you will have to drill more holes). Otherwise, just try one at a time. Put the tube through the pre-drilled holes in the plastic box. Set up the water pump to circulate water through the tube and back into the container.
4. Record the initial water temperature. Move the collector into the sun and let the system run for 20 minutes.
5. Repeat this process for each different material of tubing. Try to leave all the other variables constant (initial water temp., light intensity, flow rate of water, length of tubing, etc.).
6. Record the final temperature of the water for each tube and calculate the temperature change.



Is there a noticeable difference in the temperature reached from each tube? If so, which tube was the most efficient (greatest temperature change)? Would you have predicted this result? Why do you suppose this tube was the best?

NOTE* In this experiment, you are also using tubing of different diameters. This is another variable that affects the efficiency of the system. What do you think is the relationship between tubing diameter and water heating efficiency? Do you think this skewed your result?

Imagine that the copper tube increased the water by 22 degrees (F) and the clear plastic tube increased the water by 6 degrees (F). Copper tubing is about 5 times more expensive than the clear plastic tubing. Do you think the copper tubing is worth the extra expense for the increased efficiency?

Real World Applications

The model solar water heater you construct will very closely resemble this model that a hobbyist made in Hawaii.

This system uses a water pump to push water through the coiled tubing. With 100 feet of tubing, he is able to store about 5 gallons of VERY hot water without the use of a storage tank. Notice the sheet of glass pane on top.

This entire system was constructed for about $30 and stores enough hot water for a good shower! The system paid for itself in energy savings in less than a month.

Read more about this project here:

http://www.thesietch.org/projects/solarthermalpanel3/index.htm







Here is another simple design for a real, functional solar water heater. This design uses all recycled materials and cost about $5 to construct!

After a couple hours in the sun, this system heated 5 gallons of water from 70 degrees (F) to 110 degrees (F). The outside temperature was 76 degrees (F). Apparently, if water is allowed to sit still in the collector, it can reach temperatures of 170 degrees (F)!

You can read more about this project here:

http://www.thesietch.org/projects/solarthermalpanel2/index.htm